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WAR DEPARTMENT

TECHNICAL MANUAL

TOPOGRAPHY AND SURVEYING MAP REPRODUCTION

April, 1942

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TECHNICAL MANUAL

TOPOGRAPHY AND SURVEYING MAP REPRODUCTION IN THE FIELD

Prepared under direction of the Chief of Engineers

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Washington, April 1942

* **This manual supersedes TM 2180-37, January 2, 1940**

Section I

PURPOSE AND SCOPE

1. Purpose.— The purpose of this manual is to provide a text suitable for the training of military personnel in the methods of map reproduction used in the field, and to afford a working guide of the detailed procedure to be followed. Sufficient general theory is incorporated to afford an understanding of the principles involved in the various processes and to develop an assurance of adapting the procedure to the local circumstances that may be encountered.

2. Scope.— The scope of this manual will concern itself primarily with the photographic and lithographic methods used in the translation of data compiled by aerial and ground surveys into map editions required by other branches of the Army, but will also include details of associated reproduction systems available for local requirements and overprinting. All operating procedure will be sufficiently general to include the several available types of equipment, and information concerning adjustments peculiar to a particular machine shall be obtained from instruction pamphlets furnished with the equipment.

Section II

THEORY OF REPRODUCTION PROCESSES

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3. General theory.— Map reproduction is generally understood to include the various methods for obtaining duplicate prints from a picture or drawing containing geographic and similar pertinent detail of a particular area of the earth's surface. These methods may be broadly classified as photographic and mechanical, in that the former depends upon the action of light, with the possible assistance of chemical agents, to furnish the duplicates on sensitized sheets of paper or film,

while the mechanical methods bodily transfer a layer of ink from the design areas of a printing plate on to a sheet of paper. The photographic methods possess the advantage of conveying greater accuracy of detail in their reproductions but are slower and more exacting in their requirements than the mechanical systems. Yet the advantages of both have to a large extent been successfully combined in the photo-lithographic and similar printing processes.

4. Photography.— Photography can be literally defined as "writing with light", for in all of photography light is utilized in various ways to write its message as a visible picture on a sensitized surface. This picture may be composed of particles of metallic silver, or stained in dyes, or burnt into organic materials. It may become evident by its own action, or may leave an invisible record that will require subsequent chemical treatment to become intelligible to us.

But light need not be visible itself in order to produce these pictures, for visible light, as we know it, represents a comparatively narrow region of radiation to which our eyes are sensitive (Figure 1). Beyond these regions, into the infra red, and far into the ultra violet, there is light just as capable of writing its message as that which we can see. And this invisible light, by its increased range of penetration, can reveal pictures to use vastly different from that which we may appear to observe.

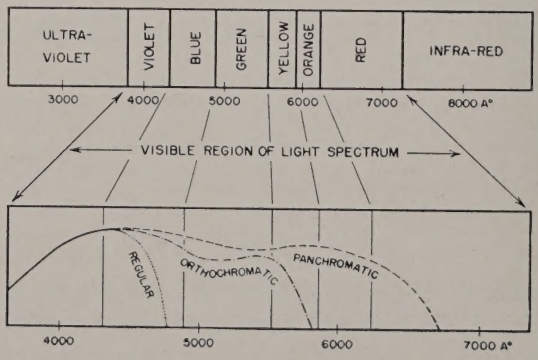

Figure 1. Relative Sensitivity of Negative Emulsions to Light.

Light, too, can "speak" many languages, and in order that we may understand its message, or translate it into another that we can comprehend, it has been necessary to design instruments to control and record its activity. The prism, lens,

mirror, camera, and sensitized materials such as negatives, and photo-prints, are a few of the specialized tools used in transcribing its story.

While we do not know the exact nature of light, its properties sometimes indicate it to be a wave motion comparable to the expanding ripples of water in a pond, and in other circumstances we can regard it as a barrage of minute high speed projectiles fired from its radiant source in machine gun fashion. Yet regardless of its nature, we have learned how to control it, and to make it work for us.

The simplest method of control is that of casting a shadow, for by using a shield or stencil and placing it in the direct path of a source of illumination we can let more or less light pass through the openings of the stencil to the material behind it that we wish to expose. This is the basis of contact printing.

The stencil is a primary aid in enabling us to produce duplicates or prints from a design, letters, or from a sketch of an object. By further utilizing light to photographically prepare this stencil for us, we can obtain far more detail and exactness than could be drawn into it by hand. We call this light prepared stencil a "negative."

The negative is usually made in a camera, consisting essentially of a box from which all light is excluded except that coming through a small especially prepared window of glass known as the lens. This lens is capable of projecting an image on the back wall of the camera of whatever external object or scene it is directed towards. If we further place a light sensitive material in the plane of this image, expose it, and process it properly, we obtain the negative, that is virtually a permanent "frozen" image of the object or scene.

The light sensitive materials capable of being made into photographic negatives are available in many forms and in a wide range of sensitivity to both light intensity and color. Those that will concern us are primarily used for reproduction purposes, and are commonly designated as continuous tone, line, and halftone negatives. (See figure 2)

Continuous tone negatives show a continuous range of tonal density from the highlights (brighter portions of the subject) to the shadows, similar to that obtained from a box Brownie or amateur camera. Specialized variations of these negatives are available that have been made sensitive to a sin-

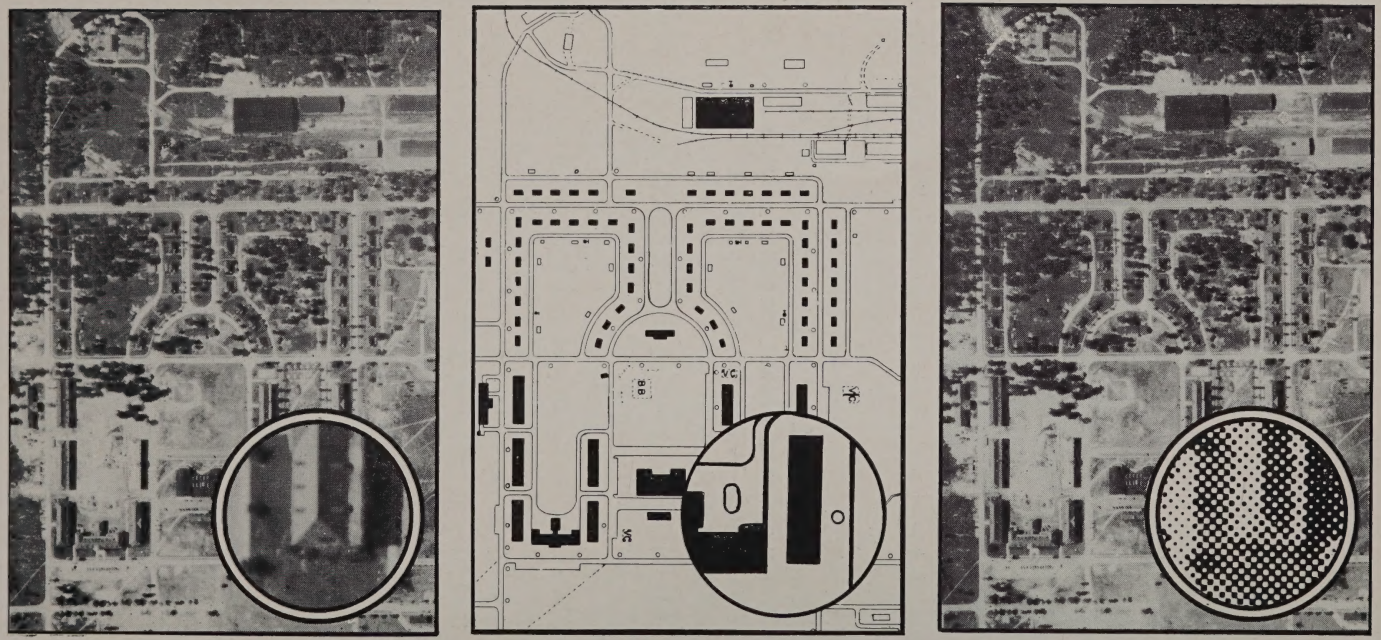

Figure 2. Process Negative Prints.

gle color or range of colors so as to offer a better rendition of the proportional color values in the subject, or for selecting a particular color out of the subject, usually with the assistance of color filters. These selected, or color-separation negatives are required in order to neutralize or exaggerate definite detail in the copy or to reproduce or print a duplicate of the subject in natural colors.

Negatives are also commonly designated as regular, orthochromatic, or panchromatic, depending upon their relative sensitivity to the visible color region. The "regular" is only sensitive to the blue end of the spectrum; the orthochromatic encompasses a wider region including both the blue and yellow portions; while the panchromatic is sensitive to all colors, as its name implies. (See Figures 1 & 11)

In color-separation work, all three types of negatives may be used, the only requirement being that the negative be sensitive to the particular color of light permitted to pass through the lens by the color filter. Although negatives are available that have been sensitized to a particular region of the spectrum, the panchromatic negative is frequently used for all separations as it enables obtaining a better control over the relative exposures and the subsequent processing required for a proper balance between the three or more color separation negatives.

Line and halftone negatives may be made out of the same materials used in making the continuous tone negatives, though as a rule they require a much slower, and correspondingly very high contrast emulsion. This is necessary as line and halftone negatives are intended primarily for use in making printing plates, and as the mechanical printing processes with which we are concerned depend upon depositing or omitting a solid color of ink on the paper, any intermediate shade of color must be obtained by depositing minute dots of ink of varying size, closely spaced so as to create the illusion of a continuous tone graduation of color. (See figure 2 c) Consequently, the printing plate, and the negative as well, must have sharply defined printing and non-printing areas. In the line and halftone negatives this will take the form of clear transparent "windows" representing the printing areas, and opaque, light-proof "walls" representing the non-printing areas.

The negatives largely used in reproduction work consist of a glass or film base coated with a thin layer of gelatin in

which fine particles of a light-sensitive silver salt (such as silver bromide) are uniformly suspended. The particular kind of silver salt used, and the method by which it was prepared, will determine its relative sensitivity to light, or speed rating. This relative sensitivity indicates that a definite amount of exposure to light is necessary to correctly "expose" each type of negative, and that it is in turn dependent on the intensity and color of the light reaching it, and on the total time of exposure.

While prolonged exposures to light will sometimes "burn" in a picture, the negatives used for photo-mechanical purposes show no visible effects of the light action, and the latent image created must be brought out by use of a developer. This developer consists of a solution of certain chemicals that have the ability to select and reduce the particles of the silver salt in the negative emulsion into black appearing metallic silver, in proportion to the relative amount of light to which they were exposed. The remaining unexposed silver salts in the negative emulsion are then dissolved away with a "fixing" solution, so that only a negative image of the subject in metallic silver remains suspended in the emulsion.

5. **Lithography.**— Printing is generally understood to be a process for making duplicate impressions from type or plates in which the ink depositing areas are either raised above or engraved below the non-printing areas, and where the ink is mechanically selected and transferred from the printing form to the paper.

In offset or lithographic printing, the selection of ink by the printing form is chemical rather than mechanical, and depends upon the general principle that oil and water will not mix. There are ordinarily no raised or engraved areas on the lithographic plate, and the ink selection is accomplished by using a base material that is receptive to both water and grease, but once a portion has been either greased or dampened, the dampened area will repel grease, while the greasy area will repel water yet accept a greasy ink. By greasing-in definite areas of the printing plate to represent words, roads, or illustrations, then treating and dampening the remaining surface, an ink selective printing form is obtained.

Alois Senefelder was the discoverer of this method of printing, and as he originally used a limestone slab on which he had lettered or sketched his printing subjects, he called

the process Lithography, that literally translated is "stone writing", or writing with stone.

The stone printing form is still used in certain fields of work, though it has been largely suplanted by metal plates (chiefly zinc or aluminum) that have been treated to provide them with the same grease and water receptive and repellent properties possessed by the lithographic stone. The metal plates are both lighter in weight and flexible, permitting ease in handling in the preparatory stages, and in the printing operation, where they can be strapped around the cylinders of the high speed rotary offset presses.

The lithographic printing surface can be greased in a number of ways, all of which are applicable to map reproduction. Grease may be applied with a brush, ruled in with a ruling pen, drawn with crayons, or rubbed into engraved lines cut through a protective dried gum coating. And finally the lithographic plate can be prepared photographically by coating it with a light-sensitive solution, then exposing it through a negative, and processing it to obtain the required greasy printing areas.

The photographic method is most generally used where a suitably prepared copy or drawing is available, while the hand methods find frequent application in some map or similar work where the original drawing cannot be satisfactorily reproduced by photographic means, or where color areas are to be added to the printed map, as may be required for roads, woods, or bodies of water. The hand methods are also used for making corrections or additions to existing plates.

The photo-lithographic plate is prepared by coating the grained surface of a sheet of zinc or aluminum with a light-sensitive solution, such as that made with albumen (whites of eggs) and ammonium dichromate, that when dried as a thin layer, has the property of becoming insoluble in water when exposed to a bright light. When a line or halftone negative is superimposed on the sensitized plate, and the plate then exposed to light so that ony those areas beneath the clear portions of the negative are affected, the sensitized coating will be selectively "light hardened" as a positive image of the negative. The entire albumen coating is then greased with a thin film of developing ink, and when subsequently placed under water, the unexposed albumen areas will dissolve away down to the original grained metal surface while the exposed and

now insoluble areas will adhere to the plate and retain their greasy ink covering. A final chemical treatment desensitizes the cleared metal areas of the plate so as to make it both water receptive and grease repellent. (See figure 3)

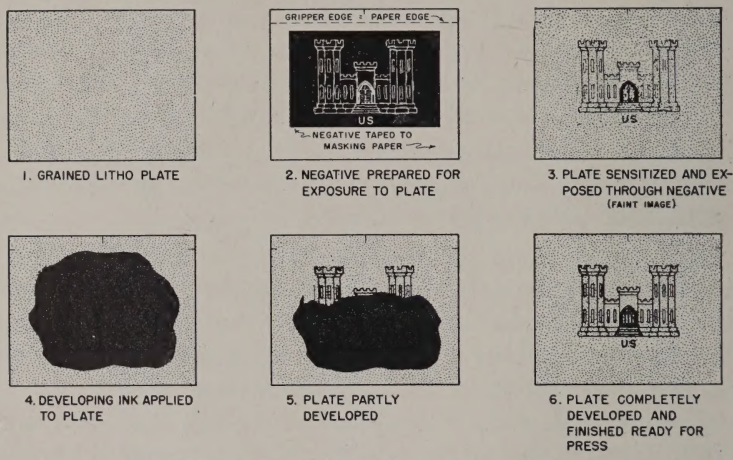
GRIPPER EDGE
PAPER EDGE
US
NEGATIVE TAPED TO MASKING PAPER
1. GRAINED LITHO PLATE
2. NEGATIVE PREPARED FOR EXPOSURE TO PLATE
US
3. PLATE SENSITIZED AND EXPOSED THROUGH NEGATIVE (FAINT IMAGE)
4. DEVELOPING INK APPLIED TO PLATE
5. PLATE PARTLY DEVELOPED
US
6. PLATE COMPLETELY DEVELOPED AND FINISHED READY FOR PRESS

Figure 3. Offset Plate Processing.

Although it is possible to print directly from the lithographic plate, it has been found advantageous to use the offset method, whereby the inked image is first printed on to a rubber blanket, which in turn transfers or "offsets" the image on to the sheet of paper. The indirect method tends to lengthen the life of the plate, reduces the transfer of water from the plate to the paper, and permits printing on a variety of surfaces, because of the resilient nature of the rubber. This method of printing is the basic principle controling the design of the modern offset press.

The offset press consists essentially of a structure supporting three cylinders in rolling contact with each other. (See figure 4). The press-plate is strapped around the upper or "plate cylinder", against which two sets of smaller supply rollers ride in contact;—the "dampeners" that moisten the plate surface;—and the "form" rollers that deposit a film of ink on the undampened greasy printing areas. The intermediate or "blanket" cylinder, carries a fabric reinforced rubber blanket stretched over its surface, and the lower or "impression" cylinder is equipped with grippers to hold the sheet of paper while it is being printed upon as it is carried between the impression and the blanket cylinders in its travel from the "feed" to the "delivery" of the press.

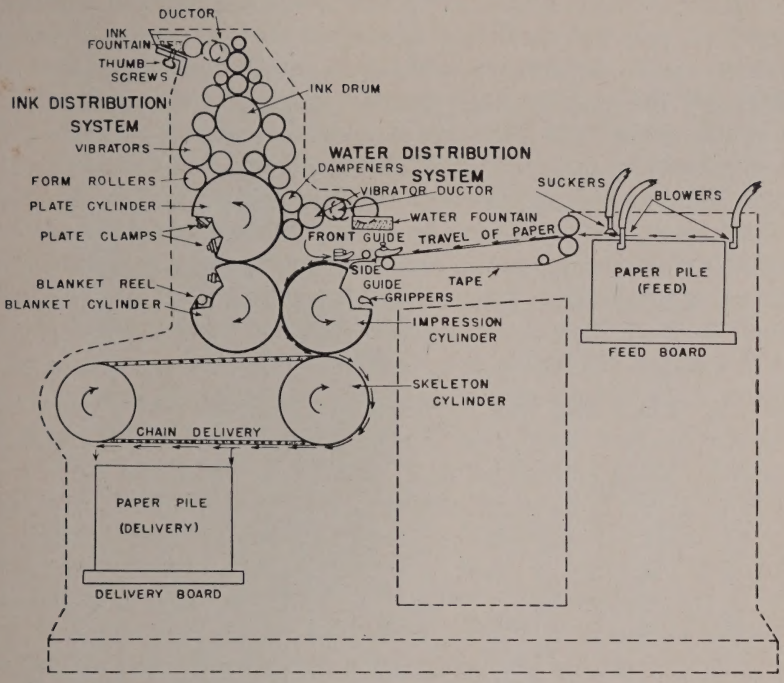

Figure 4. The Offset Press.

6. Gelatin duplicator.— The gelatin duplicator process is sometimes known as the hectograph process, derived from hecto (or 100) and graph (or write) implying a capability of writing one hundred times. It is a simplified form of printing

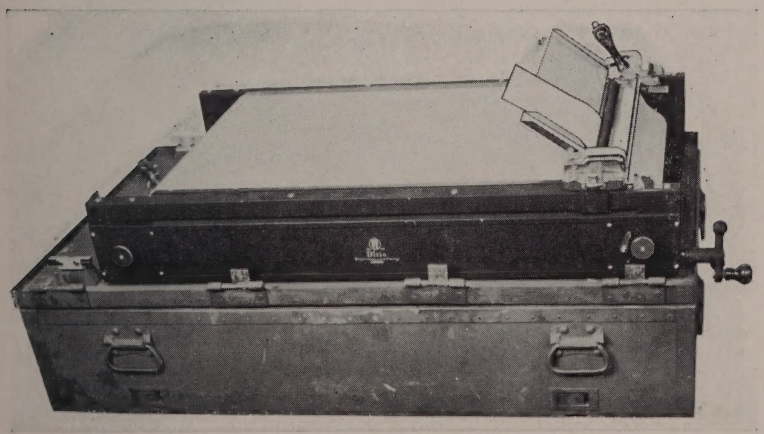

Figure 5. Gelatin Duplicator.

whereby a design prepared on a master sheet with an analine dye ink, pencil, typewriter ribbon, or carbon paper is transferred to the surface of a moistened gelatin film, that absorbs some of the ink from the master sheet, and can in turn be made to yield from 25 to 100 impressions on paper before the ink remaining in the gelatin has been exhausted to the extent that further prints are illegible. The gelatin surface is provided on a paper roll backing so that upon completion of one printing subject it can be reeled up to expose a new area for printing while the previous inked image is gradually absorbed into the coating so that the gelatin surface can be reused after a few hours. (Fig. 5)

7. **Black and white process.—** The black and white process, frequently designated as the B&W, is essentially a direct positive photographic printing method, in which the B&W paper is supplied already coated with a light sensitive dye (diazo compound), so that when exposed to a bright light through a tracing, drawing, or print on a translucent or transparentized base, the exposed areas of the dye are decomposed or bleached by the action of the light, while the remaining "shadow" of the design can be blackened by dampening it with a special developer. The B&W process is similar to the Ozalid and other commercial methods replacing blue prints. All are based on

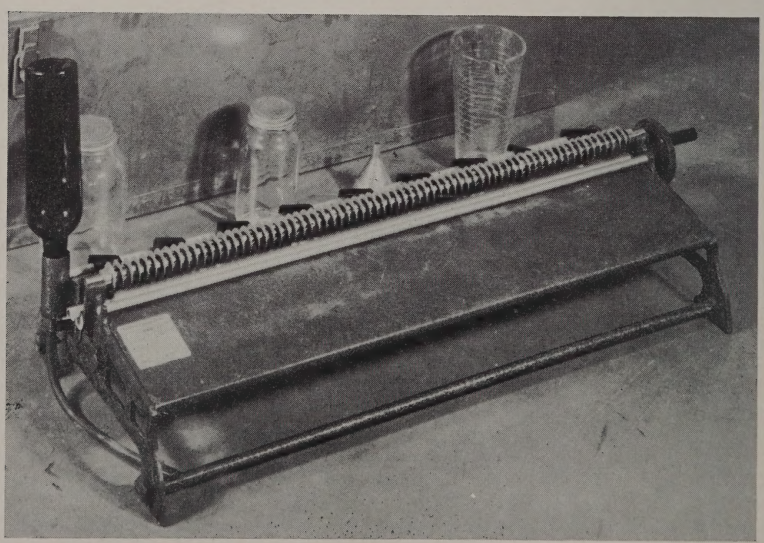

Figure 6. Black and White Developing Machine.

the use of light sensitive diazo dyes, having the advantage of providing direct positive prints from the original with either dry (ammonia fumes), or moist development that does not seriously wet and distort the paper base, and avoids the usual washing and drying operations normally required in the production of photographic prints. (Fig. 6)

8. Sepia print process.— The sepia print process, also known as the vandyke process, is similar to blueprinting in its required exposure time and limited range of tonal graduation, but provides a brown rather than a blue negative print of the original. It is chiefly used to produce contact negatives from tracings or transparentized prints that can subsequently be utilized for making photo-lithographic plates or for duplicating positive prints on blue print or sepia print paper. It is also valuable for quickly obtaining "proof" copy from map or similar negatives, as the exposure to a bright light will provide a temporary visible print of correct dimensions without the necessity of development. Sepia print paper is sensitized with a combination of an iron and a silver salt in a gelatine coating, and if permanency of the print is desired following exposure, it can be developed with water and fixed with a weak hypo solution.

9. Blue print process.— The blue print process was once extensively used for obtaining duplicate prints from drawings or tracings required for manufacturing and architectural purposes, but is now largely superceded by the ozalid, B&W and similar direct positive methods. The process remains of considerable value in map reproduction in providing a method for obtaining blue key outline prints from a master negative on one or more metal mounted paper or lacquered metal drawing surfaces, so that the individual detail for each printing color can be inked into exact register with the other colors. The light blue outlines are easily eliminated photographically on the camera when exposing the final map negatives for photo-lithographic production. In a similar manner, the offset press-plate can be sensitized with the blue-print solution, so that exposure through the negative will provide a blue image on the plate that will serve as an outline guide for greasing in definite areas required for another printing color. The blue-print sensitizer consists of a solution of a light sensitive iron salt (citrate of iron and ammonia in combination with potassium ferricyanide) that when dried on the surface of the

paper or plate, will be decomposed by the action of a strong light so that only the exposed areas will turn blue when subsequently placed in water for development.

10. Stencil duplicator process.— The stencil duplicator, (Mimeograph) is a printing method for transferring ink to the paper sheet through perforated openings in a wax coated fibrous stencil strapped around the ink supply drum of the mimeograph machine. The stencil can be prepared on a typewriter, or "cut" by hand with a stylus. A photographic stencil can also be prepared by exposing a sensitized gelatin coated fibrous base sheet to a bright light through a line positive or tracing and then developing it out by dissolving away the unexposed gelatin coating so as to provide the ink transferring openings in the stencil. (Fig. 7)

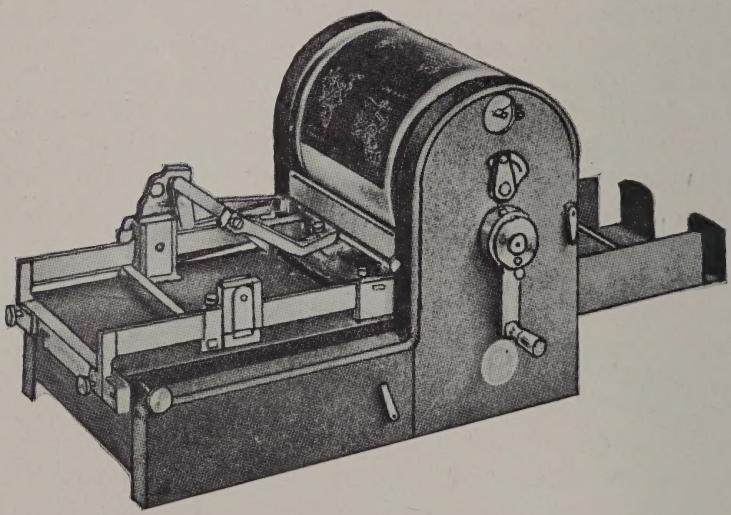

Figure 7. Stencil Duplicator.

Section III

PROCESS PHOTOGRAPHY

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11. Process Camera.— The process camera used in map reproduction work consists of a rigid spring suspended "floating" structure supporting a plate camera complete with its lens, bellows, and negative holder;—and a movable coypboard with attached arc lamps capable of being positioned along rails on the structure so that the copy can be brought closer to or away from the camera, in this way controlling the amount of enlargement or reduction obtained. The negative end of the structure is attached to the darkroom wall through a flexible connection, that in effect, makes the entire darkroom a part of the camera. This enables the operator to expose and process the negatives directly, without the necessity for using plate holders. (See figure 8).

The lens is the "eye" of the camera. It can "see" the copy to be photographed and in turn project its image on the ground glass or negative surface in the camera back. While a simple lens, such as a reading glass, is capable of forming an image, yet this image will not only lack sharp definition, but will be distorted, and show color fringes due by its variable response to the different colors of the spectrum of which white light is composed. A lens suitable for map reproduction must be corrected to eliminate these distortions, and to provide a sharply defined image over the entire area of the negative in exact proportion to that of the original copy. Lenses showing a fairly high degree of such correction are available, and may be termed as anastigmatic, or process, or called by some trade name such as Apotessars, Apochromats, Gotars, Artars, etc.

While a good lens is needed to obtain a sharply defined image on the negative in exact proportion to the copy, it is equally important that the camera be accurately and rigidly constructed so that there will be no movement of the image on the negative while the exposure is taking place, and also so that the copyboard, lensboard, and camera back will be perfectly parallel to each other for all positions along the camera rails. Otherwise distorted negatives will result similar to that obtained with an amateur camera that is moved at the moment of exposure, or is pointed diagonally upwards in photographing a building.

The lens and copy board must also be exactly positioned for each ratio of enlargement or reduction required in order that exact size and sharpness of definition in reproduction be obtained. This positioning may be accomplished by critical

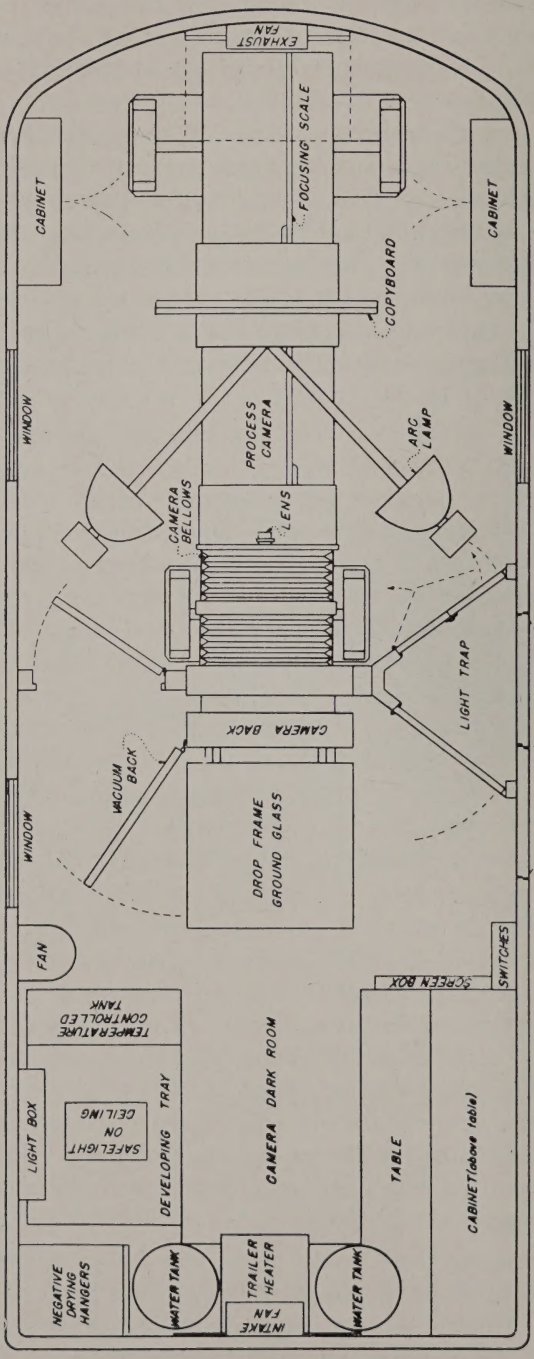


Figure 8. Mobile Copying Camera Unit.

focusing with a magnifier and checking of measurements on the ground glass, or by "automatic" focusing in locating the lens and copyboards to a scale indicator that is calibrated to the lens in use.

Where ground glass focusing is required, an understanding of several simple lens formulas will aid in more quickly obtaining exact size and focus. These equations also form the basis for the calibrations on the scale focusing cameras, and are:

Distance from ground glass to lens =

Focal Length x (1 + Magnification)

Distance from lens to the copy =

$$\text{Focal Length x } (1 + \frac{1}{\text{Magnification}})$$

For approximate distances, the center of the lens can be taken as the point for all measurements, though in exact calibrations, two theoretical points within the lens known as the nodal points, must be used. Referring to the lens formulas, if a lens having a focal length of 24″ is used for same size of reproduction (1:1 Magnification), then the distance between the ground glass and lens will be 24 x (1 + 1) or 48″. Likewise the distance from the Lens to the copy will be $24 \text{ x } (1 + \frac{1}{1})$ or also 48″. Therefore the total distance between the ground glass and the copy will be approximately 48 + 48 or 96″. For an image one half the size of the copy:

Distance from ground glass to lens, 24 x (1 + ½) = 36″

Distance from lens to copy, $24 \text{ x } (1 + \frac{1}{\frac{1}{2}}) = 24 \text{ x } (1 + 2) = 72''$

Total distance, ground glass to copy, 36″ + 72″ = 108″

For an image 1½ times the size of the copy:

Distance from ground glass to lens, 24 x (1 + 1½) = 60″

Distance from lens to copy, $24 \text{ x } (1 + \frac{1}{1\frac{1}{2}}) = 40''$

Total distance, ground glass to copy, is 60″ + 40″ = 100″

By studying these and similar calculations it will be seen that if the camera is positioned for same size of reproduction, the distance from the ground glass to the lens, and the distance from the lens to the copy will each be twice that of the focal length of the lens. If the image is to be enlarged to greater than same size, both the lens and copyboards will be moved

away from the ground glass. If, however, reductions are to be made, then the lens will be brought nearer to the ground glass, while the distance to the copyboard will be increased.

It was previously stated that there is only one correct exposure time for each negative material used, and that this exposure is dependent on the intensity of light reaching the negative, and the time interval over which it takes place. The time element can be fairly accurately controlled, but the effective light intensity reaching the negative will be conditioned by several factors. They are the intensity of the light source, its color, distance, and angle of incidence to the copy, the nature of the copy itself, the lens diaphram opening used, the distance between the lens and the negative, and the exposure factor required by the color filter and the halftone screen when these are introduced. All of these factors can be reduced to a minimum by keeping the camera arc lamps at a constant angle and distance from the copy, and by use of a diaphram control system, to keep the light intensity reaching the negative constant regardless of the varying distances between the lens and negative required for the different ratios of enlargement or reduction.

The exposure of a line negative is a simple procedure similar to that required for making a satisfactory negative with an amateur camera, but the production of a halftone negative necessitates additional attention to the lens diaphram opening used, and to the correct positioning of the halftone screen.

There are several theories to explain the formation of the halftone dots on the negative behind the screen, but whether they be due to the shadows cast by the rulings, to the lens effect of small openings, or to interference of light between these openings, we do know that with the proper screen distance and a corresponding lens stop opening, we obtain sharply defined dots of various sizes whose diameters are proportional to the intensity of light reaching the negative from the corresponding area on the copy. Thus a brighter area on the copy will transmit more light and result in a larger dot on the negative than that produced by a darker area.

The recommended screen distance and stop openings are usually incorporated into the diaphram control system, but where these are not available, an approximate means of obtaining their adjustment to produce satisfactory negatives is detailed in the following paragraphs on camera operation.

12. Camera Operation.— *Preliminary Procedure:*

Before undertaking operation of the camera, the following procedure must be adhered to:

a. Oil the rails, gears, shafts, vacuum pump and other moving parts of the camera with the exception of the lens and the lens diaphram control.

b. Make certain that the lens is securely mounted in the lensboard, and that the lensboard itself is locked in position.

c. Remove the lens cap placing it face downward so that it will not collect dust, and wipe the lens carefully with a clean sheet of lens tissue, only if accidental finger marks or a dust accumulation necessitates it. Avoid handling or cleaning the lens more than is absolutely necessary as it is the most delicate part of the camera and can be easily injured.

d. Slide the Camera Lamps to the end of their supporting arms and lock them in position. Then insert carbons, and adjust them so that they meet centrally, and can be separated by at least 1½″ when the arms are pulled apart. The arc lamps should be directed towards the copyboard at an angle of about 45°, and the reflectors adjusted so that no direct light from the camera lamps can reach the lens. It is advisable to mark the position and angle of the lamps on their arms so that return settings for standardized exposure can be maintained.

e. Clean the copyboard glass, using a soft rag with a little ammonia water or carbon-tetrachloride as needed to remove any dust or spots on its surface. Do not use razor blades or any other abrasive material in cleaning the glass, as the resulting scratches will photograph on every negative made.

f. Prepare all the necessary developing, washing, and fixing baths, first washing out the tanks or trays and cleaning the graduates, pails, and stirring rods or paddles used. Then mix the developing and fixing solutions, bringing their temperature to as close to 65° F as possible and pour them into their respective tanks. The water should also be kept at as close to 65° F as possible, using the temperature control system or any improvised heating and cooling means that may be available.

13. Camera Operation.— *g.* Examine the copy to be photographed, removing dirt spots with an artgum eraser where so doing will not injure the copy or delete work drawn on it.

Where the copy is to be used for preparing two or more separation negatives for subsequent printing of the map in several colors, make certain that center marks and corner or trim marks appear along the margins outside of the normal trimmed area of the map. These will consist of short lines, about ¼″ long, drawn in India ink on the map or on small tabs of paper temporarily attached to the map, to indicate the location of the center lines and the trim area of the map, and to also serve as register marks for the subsequent use of the pressman in printing the several colors. (See figure 9)

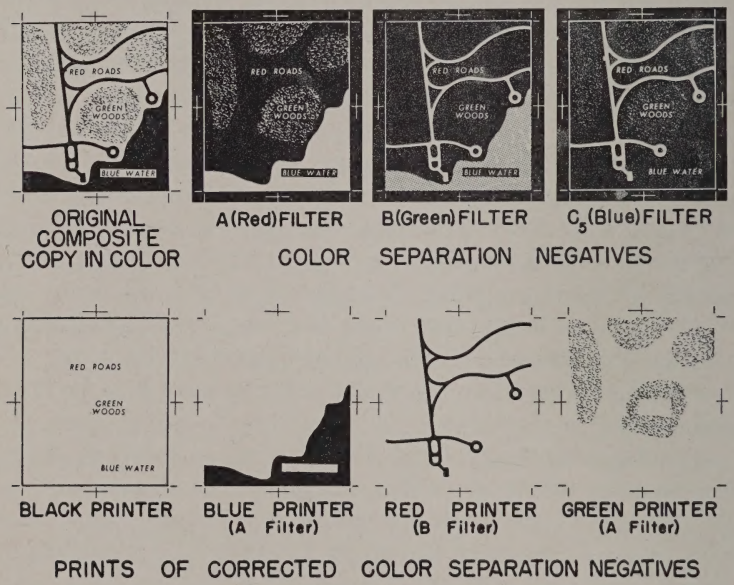


Figure 9. Color Separation.

h. Tilt the copyboard into horizontal position by first releasing the catch at its base, unhook the latches and raise the upper glass frame of the copyboard until it catches and holds in the raised position. Then place the copy centrally in the copyboard. In this connection it is advisable to obtain a sheet of heavy white paper, the same size as that of the copyboard, and draw light blue center lines, rectangles, and diagonals across it, then carefully mount and tape it centrally to the spring back of the copyboard. The copy can then be placed on it and quickly centered to the blue lines. (See figure 10.) Dust the copy carefully with the camel's hair brush, lower the glass frame and secure the latches, release the catch and tilt the copyboard back into vertical posi-

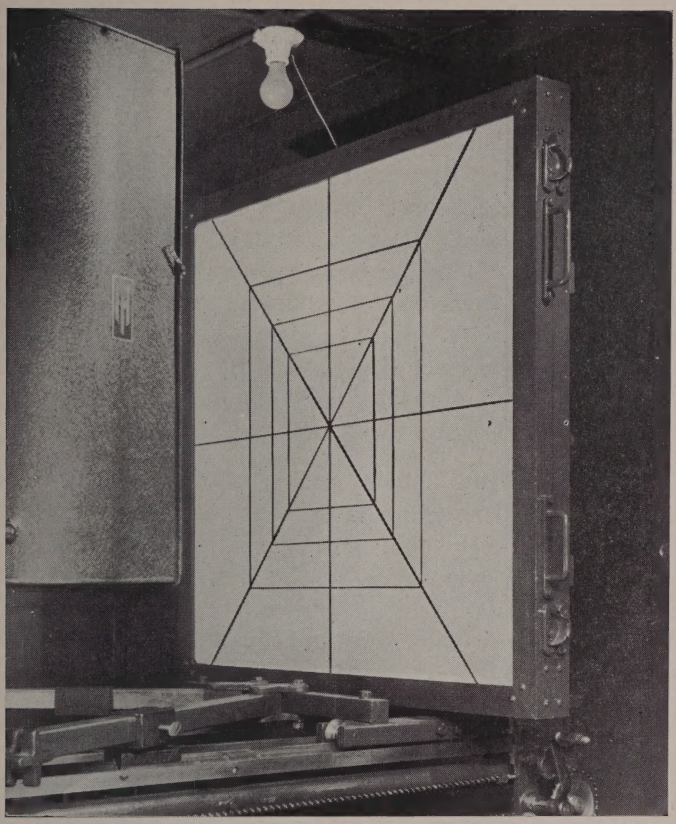


Figure 10. Camera Copyboard.

tion, examining the copy and the glass again to make certain no dirt or dust appears over its surface.

i. Next, move the copyboard and lensboard carriages to the particular ratio of enlargement or reduction required for making the negative from the copy, or if some odd ratio other than that marked on the focusing scale is necessary, locate them to the nearest indications on the scale. Then secure the lensboard drive shaft with the hand lock.

j. Open the lens shutter and the lens diaphram to its maximum opening, switch on the arc lamps, and examine the image of the copy on the ground glass in back of the camera, (first making certain that the screen mechanism has been withdrawn and that the ground glass has been fully lowered into contact with the camera back). By means of the lensboard adjustment controls, move the image vertically or horizontally until it is centered on the ground glass.

k. Then check the dimensions of the image by use of the beam compass, (or by dimensional markings made with a needle or knife blade on tabs of cellulose scotch tape attached in position on the grained side of the ground glass). If adjustments are necessary, change the lens and copyboard positions by means of the controls in the darkroom until exact size, and critical focus, as indicated by use of the focusing magnifier, is obtained. This can most easily be accomplished by first moving the lensboard away from the ground glass for a larger image, or towards the ground glass for smaller image, (making all such movements in small stages), and adjusting the copyboard to return the image into focus. (The copyboard will be moved away from the ground glass for increased size in enlargments and for decreased sizes in reductions.)

l. Close the lens shutter; set the lens diaphram control so that the F/32 line is in agreement with the number indicated on the dial on the side of the camera, (this automatically compensates for the position of the lens), turn out all lights in the darkroom behind the camera with the exception of the safelights, and close the darkroom door.

m. Before making the first negative, and subsequently at the beginning of each day or every time a new type of film is used, it is advisable to make tests to verify the exposure time required by the different types of film, and to check the condition of the developing and fixing solutions. This is accomplished by first mounting a suitable copy or grey scale in the copyboard, positioning the camera to required size of reproduction, and setting the lens diaphram control. Then taking a small strip of film, attach it to the vacuum back by vacuum suction, or with several pieces of self-adhesive tape. Raise the ground glass to clear, swing the vacuum back into exposure position, turn on the camera lamps, and expose the film by opening the shutter for the required time; then close the shutter, and switch off the arc lamps. With Kodalith film under these conditions the first exposure should be about 40 seconds, with the lens stopped down to F/32. The exposure times for the several negative materials used with the lens stopped down to F/32, for same size of reproduction, (based on Weston Light Meter Reading of 225 f. c. on white copy) are.

Kodalith Ortho	40 sec.
Kodagraph Pan	2 sec.

Commercial Ortho ---------- 1 sec.
Reprolith Pan ---------- 30 sec.

The film is then removed from the vacuum back, and immersed into a freshly prepared developer. If the temperature of the solution is between 65 and 70° F, the image will appear on the film in between 30 and 45 seconds, if correctly exposed. Should the image appear sooner, over-exposure is indicated, and another test strip must be exposed for a shorter time until the image appears within the 30 to 45 second period. Conversely, if a longer time is required for first appearance of the image, then the exposure time must be increased until it appears within the specified time. Full development will be reached within two to three minutes, depending on the time required for first appearance of the image, and the temperature of the developer, though under conditions where these cannot be properly controlled, the total developing time should be about four times that required for the first appearance of the image. Other films will require different exposure times as well as special developing solutions, and similar test shots should be made with them. Commercial Ortho film, for example, is about forty times as fast as Kodalith and will require one-fortieth the exposure, that is,—if Kodalith film requires 40 seconds for proper exposure with a particular lens diaphram setting, then Commercial Ortho film substituted for it, will require only one second exposure time. It is imperative, of course, that the proper color of Wratten safelights be used with each change of film, as the series II light that is satisfactory for Kodalith, will fog panchromatic films. (See Figure 11) After the correct exposure time for a particular film has been determined, it will remain fairly constant for that film, so long as the lens diaphram opening is properly adjusted, and the arc lamps retain the same distance, angle to the copyboard, and light intensity. The use of filters, or of copy prepared on a paper that is not white, but tinted some other color, or the introduction of a halftone screen, will all increase the exposure time required, and each condition will be dealt with later.

n. When the correct exposure has been made with a test strip, the full size of negative required will then be mounted centrally on the vacuum back of the camera, opening such sectional vacuum valves as are necessary to hold the film flat. The vacuum back is then closed into exposure

position, the camera lamps switched on, the shutter opened, and exposure made exactly the same way as was determined to be the correct procedure and exposure time with the test strips. The film is next removed from the camera and prepared for development by attaching it in a taut condition in the film frame and then placing it in the developing tray or in the tank for the required two to three minutes as determined with the test strip. The frame must be raised and lowered several times during development or the tray rocked slightly to agitate the developing solution so that uniform development of the film will result. Upon completion of development the negative is removed from the tray or tank, then lowered and agitated in the washing tank for about ten or fifteen seconds, and placed in the fixing tank, where it is allowed to remain for five or more minutes, or at least a full two minutes after the last traces of undeveloped silver bromide has been dissolved away to form the transparent areas of the negative. The negative is next suspended in the washing bath for about a minute, then removed and examined over a white light or against a white sheet of paper. If the

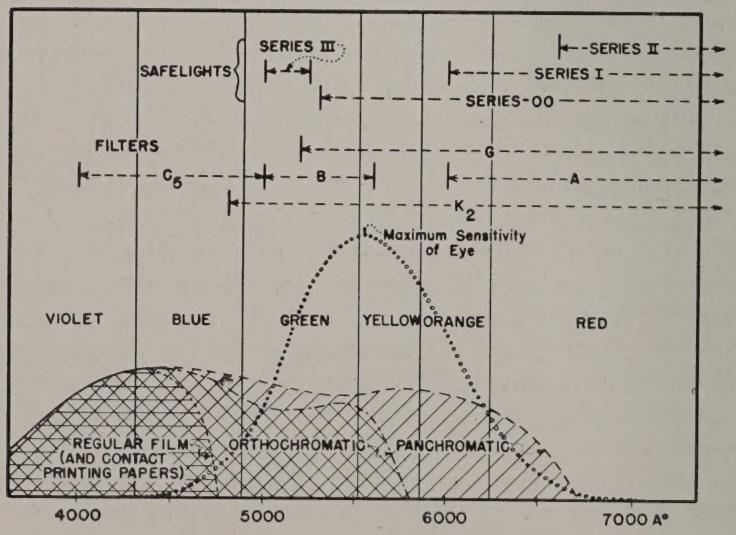


Figure 11. Light Transmission Ranges for Safelights and Filters.

clear areas are perfectly transparent, and the exposed areas sufficiently opaque, the negative is again lowered into the washing bath for about ten or fifteen minutes, allowing a slow stream of fresh water to circulate through the bath for

this time. If the negative apears veiled or fogged when removed from the fixing bath so that the transparent areas show a decided greyness when placed on a white piece of paper, due either to light fog, grey copy, or to too warm or old a developer, then the negative should first be cleared with a clearing solution before being given the final wash. The clearing solution is made up from the prepared chemicals in accordance with the instructions appearing on the container. (Also see formulae) The film negative is immersed in this solution, or sponged with a clean tuft of cotton repeatedly dipped into the solution for a period of from five seconds to half a minute or more, until the transparent lines are no longer clouded but show clear against the tray, on the light table, or against a white piece of paper. After clearing, the negative is returned to the washing bath and washing continued for ten or fifteen minutes as required for the normal film. The negative is then removed and carefully blotted between two sheets of lintless blotting paper or the surplus water can be removed with the assistance of the cellulose sponge. The film is finally suspended in a rack or on a line near a fan so that the circulation of air will assist in its drying.

o. The negative is now ready for the work required to prepare it for exposure to the press-plate, but before being released, the dimensions of the image and the other data should again be checked to guard against errors. (In this connection a slight variation in size may be noted due to stretch or shrinkage of the film as a result of its retained humidity.)

14. Halftone Negatives.— Halftone negatives are required for printing reproductions of continuous tone graduations similar to those encountered in illustrations or aerial photographs, or for preparing tints of the darker printing colors, such as utilizing the dark blue printing plate to provide the light blue tones representing the bodies of water. In color process reproduction, halftones are also used to blend the colors together, in varying tints, so that the appearance of the many shades and colors in an oil painting or in a natural color photograph can be reproduced with only three or four printing inks.

The material, equipment, and solutions required for making halftones are similar to those used in line work, with the exception of the addition of the halftone screen. The instruc-

tion manual furnished with the diaphram control system provides complete details of the process, but as this manual is based on the broad requirements for all fields of printing, the following simplified procedure for producing halftone negatives from aerial or other continuous tone photographs should be followed:

a. Examine and prepare copy, clean copyboard glass, and finally place copy on the copyboard as described in paragraphs 12 & 13 under CAMERA OPERATION, adding a gray scale along one side of the copy so that it will also appear on the negative.

b. Mount the halftone screen in the screen housing, with the cover glass side away from the lens (the side on which the screen ruling and serial number is engraved). Always handle the screen by its metal binding, avoiding finger prints on the glass, and dusting carefully with a camel's hair brush on both sides before using. If finger marks appear on the surface they may be removed by wiping with a sheet of lens tissue, moistening the screen by breathing on it to assist removal of the marks. A solvent such as alcohol or carbon-tetrachloride can be used sparingly, if necessary, by moistening a corner of the lens tissue, and observing care that none of the solution touches the screen metal binding, for it may dissolve the balsam cementing the screen glasses.

c. Correctly position the screen to the required screen distance at its four corners, so that it will also be perfectly parallel to the surface of the negative. The 133 line screen furnished with the Process Camera requires a screen distance of 13/64″ between the surface of the screen and that of the surface of a film negative mounted on the vacuum back. This will be accomplished as follows:

(1) Attach a film to the vacuum back that is large enough to cover the entire screen.

(2) Set the screen distance dial indicator by turning the hand screw until it reads .200″ (2 on the small dial and 0 on the large dial), or to a corresponding reading representing about 3/16″ separation on the other types of dials.

(3) Separate the rear bellows section from the darkroom connecting board, then move the lensboard forward so as to provide working space around the screen housing. (This step will not be necessary on cameras equipped with a steel bar for positioning the screen.)

(4) Select the screen distance wedge having the 13/64″ marking, and beginning at one corner of the screen, insert the wedge till it just stops upon contacting both screen and film, without applying pressure, and read the marking on the wedge alongside the edge of the screen glass.

(5) If a distance larger than 13/64″ is indicated, move the screen backwards, turning the adjusting screw in the screen support adjacent to the corner being tested, by a fraction of a turn, then check the distance again with the wedge until 13/64″ is obtained. (For distances less than 13/64″, the procedure will be similar except that the adjusting screw will be turned in the opposite direction.) After setting one corner correctly, repeat the same procedure for each of the other corners until all are positioned to 13/64″ between the screen and the negative. Finally recheck the distance as considerable adjustment at one corner may affect those already set.

(6) Upon completion of the adjustment, replace the bellows, noting that the screen distance indicator still reads .200″ or that the adjustable stop is positioned and locked to a definite setting so that the correct screen distance can be readily repeated when required.

Once the correct screen distance has been obtained, and providing the adjusting mounts have not been disturbed, future use of the screen will only necessitate its being replaced in the screen holder, and the repositioning of the hand wheel or handle to the predetermined location. The screen distance should, however, be rechecked each time the camera unit has been moved to a new location, as vibration may disturb the settings.

d. EXPOSURE: Whereas a single lens diaphram opening is used in exposing a line negative, a series of three exposures are found desirable in producing the halftone negative to provide control over the relative subject contrast required. These three exposures are called "Highlight", "Detail", and "Flash" to indicate that the Highlight exposure controls the size of the dot in the highlight areas of the negative, as well as the subject contrast; the Detail fills in all the detail of the subject, and the Flash exposure, usually made with a white sheet of paper mounted over the face of the copyboard or with a diffused light in front of the lens, "flashes" the entire negative regardless of subject detail,

providing a fine pinpoint dot that serves as a dense core in all existing dots obtained with the other exposures, and adds the same pinpoint dot over the otherwise clear portions of the negative. Two factors will condition the size of the lens diaphram openings and the relative exposure times used. They are the subject contrast and the ratio of enlargement or reduction being made on to the negative.

e. Compensations for Subject Contrast: For simplest consideration, camera copy can be divided into five groups, "Light Flat", "Medium Flat", and "Dark Flat", all requiring increased contrast in negative; "Normal", that of the average satisfactory print; and "Contrasty" where extreme contrast between the "highlights" and "shadows" on the print would ordinarily be further exaggerated in the negative. The exposure tables that follow are based on that required for normal negatives at same size of reproduction using an F/22 Highlight diaphram opening, an F/45 Detail, and an F/90 Flash diaphram opening in the lens. Where the diaphram control system is used, corrections for subject contrast can be accomplished by shifting the exposure line to the next larger diaphram opening series for an increase in contrast, or to the next smaller series for decrease of contrast. If for example, normal contrast is obtained using the F/32 line then increased contrast from dense prints can be obtained by shifting to the F/27 and decreased contrast will result from using the F/39 line in place of the F/32, decreasing or increasing the exposures by one-fourth to compensate for the smaller or larger diaphram openings used. However, sufficient control can ordinarily be obtained by changing the relative exposures on the Highlight and Detail lines, and for purposes of standardization, this method is adhered to in the instructions that follow in step "g".

f. Compensations for ratio of enlargement or reduction: The distance between the lens and the negative are increased for enlargements over that required for same size, and decreased for reductions, and in order to keep the exposure time and screen distance constant for the varying ratios of reproduction, the lens is usually equipped with a diaphram control system. This system permits the size of the lens diaphram opening to be altered in proportion to the change of distance between the lens and negative so that the light intensity reaching the negative will always remain constant.

g. Exposing the halftone negative: The correct exposure time will have to be determined experimentally here at first as was required with line negatives, due to its being conditioned by the arc lamp intensity, and the speed of the negative emulsion. Using copy of normal contrast at same size of reproduction and positioning the arc lamps so that the Weston exposure meter reading on a white piece of paper in the copyboard is about 225 f.c., the preliminary exposure times can be taken at (if light intensity on copy is greater or less than 225 f.c., alter exposure times proportionally):

Stop	Flat Copy			Normal Copy	Contrasty Copy
	Light	Medium	Dark		
Highlight (F/22 Line)	45Sec.	90Sec.	220Sec.	65Sec.	40Sec.
Detail (F/45 Line)	25Sec.	105Sec.	180Sec.	210Sec.	300Sec.
Flash (F/90 Line)	25Sec.	35Sec.	45Sec.	25Sec.	50Sec.

For all other ratios of enlargement and reduction, the correct diaphram opening for the F/22 line is obtained by first noting the number indicated on the dial on the side of the lensboard carriage, then setting the F/22 marking on the pointer attached to the lens diaphram ring so that it coincides with this number. The F/45 line openings are obtained similarly, by moving the indicator until the F/45 marking comes opposite the same number, while the flash exposures can be made by using a fixed opening of F/90 for all enlargements and reductions. As the Highlight, Detail, and Flash exposures are made successively on the same negative, care must be observed that no stray light is permitted to reach the negative when leaving and entering the darkroom for the purpose of operating the lens diaphram control.

h. Where a lens diaphram control is not provided, satisfactory halftones can be produced by carefully approximating the lens diaphram opening required for the particular line series and ratio of reproduction undertaken. The process lens is normally marked to indicate the F/11, 16, 22, 32, 45, 64, and F/90 positions for setting the lens diaphram ring, and intermediate F/numbers can be approximated or marked on an extension scale. Referring to the basic test stops recommended in step 14 e, as F/22 for Highlight, F/45 for Detail, and F/90 for Flash exposures, the corresponding values of these diaphram openings for other ratios of enlargement or reduction will be:

i.

Ratio of Reproduction	Highlight Exposure F/22 basis	Detail Exposure F/45 basis	Flash Exposure F/90 Basis		For Line Negative F/32 basis
			For Variable Flash (Constant time)	For Constant Flash at F/90 (Varying Times) Multiply time by:	
3 x size	F/11	F/22	F/45	6½ x	F/16
2¾ "	11¾	24	48	5¼	17
2½ "	12½	25	52	4	18
2¼ "	13½	27	55	3¼	19½
2 "	14	29	60	2½	21
1¾ "	16	32	66	2	23
1½ "	17½	36	72	1½	25½
1¼ "	19½	40	80	1¼	28½
1 (same size)	22	45	90	1	32
¾ size	25	51	103	.9	37
½ "	29	60	120	.8	43
¼ "	35	72	144	¾	51

j. After the Highlight, Detail and Flash exposures have been made, the negative is removed from the camera vacuum back, and placed in the developing tank or tray that has previously been brought to a temperature of approximately 65° F. The negative is developed for 2½ minutes, then immersed in the water tank for about ten seconds, and placed in the fixing tank where it is allowed to remain for at least a minute after it has cleared. Return the negative to the water tank again for a few seconds, then examine it over a light box or table with the linen tester. If exposure and development are correct, the grey scale placed on the side of the copy will show ten distinct steps, and both the grey scale and the copy will have a range of dot sizes varying from a small opaque "pinpoint" dot in the area corresponding to the blackest step (shadows), to a nearly blocked out area with small clear "pinhole" openings corresponding to the whitest step (highlights) on the copy. If the entire negative is too light so that no opaque dots appear in the shadows and on the last two or three steps, and a fairly open dot is evident in the darkest step or highlights, the negative has been underexposed, and all three exposures should be increased proportionally until the desired dot size range is obtained for all eight steps. Too dense a negative, where the smallest dots are comparatively large, and where the pinhole openings in the darker portions of the negative are entirely veiled or fogged, indicates over exposure, and proportionally shorter exposures must be given. Once the correct exposure times have been determined,

they will remain fairly constant for all normal ratios of enlargement or reduction, provided the diaphram control system is set for the ratio required, and that normal copy is used. (A small percentage increase may be found necessary for extreme enlargements and a decrease for extreme reductions.) Compensations for subject contrast by altering the proportional exposure times on the Highlight, Detail, and Flash stops will distort the grey scale but a proper dot size ranging from an opaque pinpoint in the "shadow" areas of the negative to a clear pinpoint in the "highlights" should be obtained. As a further aid in judging copy correctly for arriving at the required exposure times, a chart is included with this manual to enable the operator to establish a basis for determining the the range of contrast in the copy. (Fig. 12) The chart shows a series of nine contrasts of copy with its corresponding tone range on bordering grey scales, and can be used for directly judging the copy to obtain the required exposure times. For closer determinations, the larger grey scale alongside, or a corresponding grey scale can be used as a reflection densitometer to directly scale local areas of the copy by punching holes through each of the tone steps and numbering the steps from 1 (lightest) to 10 (darkest) on the scale. By alternately placing this scale over the lightest and darkest portions of the copy, the numbers corresponding to the matching tones will provide the basis for the required exposure times as shown in the following:

Fig. No.	Grey Scale Tone range	Highlight F/22 Line	Detail F/45 Line	Flash F/90 Line
I	1–3	40 sec.	10 sec.	11 sec.
II	1–5	50 "	20 "	11 "
III	1–7	65 "	150 "	16 "
IV	1–10 (Normal)	65 "	210 "	18 "
V	1–10 (Contrasty)	40 "	300 "	35 "
VI	3–5	65 "	15 "	13 "
VII	3–7	90 "	105 "	16 "
VIII	5–7	105 "	135 "	16 "
IX	5–10	220 "	180 "	35 "

(Screen distance — 13/64" between glass and film. Copyboard illumination on white paper — 225 f.c. — Weston Exposure meter reading. With increased or decreased light intensity, alter exposure times proportionately) (See Fig. 12).

This chart was determined with photographic copy using Kodalith orthochromatic film, and variations in the tone and color of the paper stock, or in the negative material used will alter the required exposure times. In addition the sensitivity

of the negatives may vary from batch to batch, and it is accordingly advisable to make test exposures on a small film whenever a change in the film stock or in the type of copy is encountered.

In addition, especially during the training period, retaining samples of copy of varying tone ranges and on various paper stock with correct exposure times marked, will be found helpful for judging exposures to be used on corresponding types of copy.

The diaphram control system will be found to require slight exposure compensations for the extreme enlargements and reductions, as a definite percentage increase for enlargements and decrease for reductions, though in the normal range of work encountered in map reproduction this factor can be ignored.

k. If a slight veil or fog appears in the clear areas of the halftone negative between the dots, when examined over a white sheet of paper, due to stray light, too high a developing temperature, or slight over-exposure or overdevelopment, the negative can usually be "cleared" by sponging it over a light table or in a separate tray containing the reducing solution, as described in 13 n under CAMERA OPERATION.

l. Following the fixing operation, and "clearing", if necessary, the negative is again immersed in the water tank for about ten minutes, then removed, blotted lightly with the lintless blotting paper, and suspended where a current of air from the fan will assist its drying.

m. The use of color filters in halftone making will require similar procedure to that called for in line work under the subject of Color Filters (Par. 16), necessitating the use of negatives that are sensitive to the particular color of light permitted to pass through the filter, and multiplying each exposure time proportionally to that called for by the "Filter Factor" corresponding to the filter and negative material used.

15. Safelights.— Safelight Lamps are designed for use in the darkroom and are intended to provide sufficient working light with a minumum possibility of fogging the negative in its preparatory stages. Yet no safelight is entirely safe and consequently the sensitized materials should not be exposed to them more than is absolutely necessary for inspection in the preliminary handling and development procedure. This applies particularly to the faster commercial ortho films and

the panchromatic films. The Safelight Lamp is equipped with several numbered Wratten Safelights in shades of green, orange, or red, to provide for the several sensitized materials used. A list of the sensitized materials and the Wratten Safelights that are to be used with them, follows: (See Fig. 11)

Paper	Wratten	Safelight
Contact printing (Azo, etc.)	Series	OO or OA
Bromide	"	OA or 1
Paper Negatives (Kodalith, Litholoid etc.)	"	1 or 2
Film Negatives		
Orthochratic (Commercial, Kodalith, etc.)	"	1 or 2
Panchromatic (Kodagraph, Reprolith, etc.)	"	3

16. Color Filters.— Color filters are available in sheet gelatin form for insertion into the filter slot, and also as sheet gelatin cemented between glass plates for mounting into the filter holder attached to the lens. Its purpose is to allow a particular color of light to pass through the lens, while excluding all other colors, and in this way can be used to separate the colors composing the copy. If, for example, is is desired to reproduce the roads on a printed map, in which the roads and other markings appear in black and green, and where large areas of the green representing woods, or other vegetation are to be omitted from the reproduction; inserting a green (B) filter in the lens, and multiplying the normal exposure time by the number indicated by its filter factor will blacken the green areas on the negative as if they were the color of the paper, and the black detail will appear clear on the film by contrast. Similarly, if red markings on the map are not desired on the negative, inserting a red filter, and exposing on a panchromatic film that is sensitive to the red light will provide the desired results. A tabulation of the filters, their numbers, characteristics, and filter factor with several types of films, follows: (See Figs. 9 & 11)

Note: When filters cemented in glass are to be used, they should be mounted in front of the lens after positioning the copy and lens board to the size of reproduction required, and then final critical focusing for exact size and sharpness of detail completed with the filter in position. This is necessary as the introduction of the glass filter will not only affect the location of the copyboard by introducing a new medium be-

Wratten Filter No.	Color of Filter	Used for Exposing color-separation negative for	Also for Photo-graphing	Type of Negative Required	Negatives Used	Approximate Filter Factor: (increase exposure by)
A (No. 25)	Red	Blue Printing Plate	Blue as Black; Green as Black; Orange as White; Red as White	Panchromatic	Kodagraph Reprolith Pan.	19x 7x
B (No. 58)	Green	Red Printing Plate	Violet as Black; Green as White; Orange as Black; Red as Black	Ortho-chromatic	Kodalith Ortho Commercial Ortho Kodagraph Pan Reprolith Pan	7x 40x 15x 22x
C5 (No. 47)	Blue	Yellow Printing Plate	Violet as White; Blue as White; Yellow as Black; Red as Black	Regular	Kodalith Ortho Commercial Ortho Kodagraph Pan Reprolith Pan	10x 3x 12x 17x
F (No. 29)	Deep Red	More contrast than A	See A	Panchromatic	Kodagraph Reprolith Pan.	36x 12x
G (No. 15)	Deep Yellow	More contrast than K2	See K2	Ortho-chromatic	Commercial Ortho Kodagraph Pan Kodalith Ortho Reprolith Pan	20x 4x 7x 2.5x
K2 (No. 8)	Yellow	Black Printing Plate	Blue as Black; Yellow as White	Ortho-chromatic	Commercial Ortho Kodalith Ortho Kodagraph Pan Reprolith Pan	14x 3x 3x 2x

tween it and the lens, but may also necessitate an adjustment of the lens position itself due to altering its effective focal length.

FORMULAE AND NOTES

A PHOTOGRAPHIC

DEVELOPERS:

(1). Continuous tone developer for negatives. (DK-60a)

Water (about 125°F)	96 oz.
Elon (Metol)	145 grains
Sodium sulfite, des.	6 oz. 290 grains
Hydroquinone	145 grains
Kodalk (Borax)	2 oz. 290 grains
Potassium Bromide	29 grains
Water to	1 gallon

Develop for 9 minutes at 65° F.

(2). Continuous tone developer for paper and film (D-72)

Water (about 125° F)	16 oz.
Elon (Metol)	45 grains
Sodium sulfite, des.	1½ oz.
Hydroquinone	175 grains
Sodium Carbonate, des.	2¼ oz.
Potassium Bromide	27 grains
Water to	32 oz.

For use dilute 1 part developer in 2 parts water.

For paper, develop 45 sec at 70° F.

For film, develop 4 min. at 65° F.

(3) Contrast Developer for line and halftone negatives (D-85)

Water (about 90°F)	64 oz.
Sodium sulphite, des.	4 oz.
Paraformaldehyde	1 oz.
Potassium Metabisulfite	150 grains
Boric Acid, crystals	1 oz.
Hydroquinone	3 oz.
Potassium Bromide	90 grains
Water to	1 gallon

Age 2 hours before using, keep in filled stoppered bottles.

Deteriorates rapidly upon exposure to air.

Develop 2 minutes at 65° F.

FIXING BATHS

(4). For films, plates and papers. (F-5)

Water (about 125°F)	20 oz.
Sodium thiosulphate (hypo)	8 oz.
Sodium sulfite, (des.)	½ oz.
Acetic acid, 28%	1½ fl. oz.
Boric acid, (crystals)	¼ oz.
Potassium alum	½ oz.
Cold water to	32 oz.

(5). For minimum shrinkage of negative.

Sodium thiosulfate (hypo)	32 oz.
Potassium metabisulphite	4 oz.
Water to	1 gallon

CLEARING SOLUTION (Farmer's Reducer)

(6). Stock Solution A:

Potassium fericyanide	1¼ oz.
Water to	16 oz.

Stock Solution B:

Sodium thiosulfate (Hypo)	16 oz.
Water to	64 oz.

For use add 1 pt. A and 4 pts. B to 16 oz. water

PRE-HARDNER: For negative development at high temperatures:

(Note: Kodalith film does not require hardening of its emulsion.)

(7). Formalin (40% formaldehyde) 1 fl. oz.

Sodium Carbonate (des.)	½ oz.
Water	1 gallon

Immerse for 2 to 3 minutes, wash for 1 to 2 minutes in water then develop normally.

REACTIVATION.— For reviving fogged or exposed but undeveloped process negatives.

Immerse in:

(8).—

Water	24 oz.
Ammonium bichromate	1 oz.

for about three minutes. Wash in water for 5 to 10 minutes, blot with clean blotting paper and hang film to dry. Conduct all operations under safelight. For use, multiply normal exposure time by four. Follow standard procedure for development, fixing and washing of negative.

HIGH TEMPERATURE DEVELOPMENT of Process Film.

Dilution of Developer method for constant development time, where temperature control equipment is not available:

Line Negatives		*Halftone Negatives*	
Temperature	Dilution	Temperature	Dilution
70°F	none	70°F	none
80°F	1 : 1 pt. water	80°F	1 :½ pt. water
90°F	1 : 1½ pts. water	90°F	1 : 1 pt water

CONTINUOUS TONE NEGATIVES using process (Kodalith) film

Exposure time as for line negatives.

Develop in extreme soft contrast developer, such as DK 60a diluted as follows.

1 pt. developer to 10 pts. water (6 min. at 65°) (to increase contrast)

1 pt. developer to 15 pts. water (8 min. at 65°) (for normal copy)

1 pt. developer to 20 pts. water (10 min. at 65°) (to flatten contrast.)

Advantages.— Fine grain; standard materials; can be processed at high temperatures.

CONTACT SCREENS:

Contact film screens for use either in the camera or in a printing frame in exposing halftone negatives from continuous tone subjects can be produced as described in the following. (The availablility of several such screens are recommended due to the fragility of the standard glass screens.)

Use normal screen distance. Locate lensboard to 3x enlargement. Open lens to F/11. Position white sheet of paper over copyboard about 12″ in front of lens. Mount Kodalith film on vacuum back. Expose about 2½ minutes. Develop in extreme soft contrast developer such as DK60a diluted one part to eight parts water, for six minutes. Wash, fix, wash, and dry as usual.

For using contact screen on camera, hold screen in contact with negative by vacuum. (A larger clear acetate or cellophane sheet to cover the screen film and negative can be used if necessary to obtain vacuum) Expose about 3½ minutes on F/22 line.

For use in a contact printing frame in obtaining halftone negatives from continuous tone positives, place screen between positive and film. Exposure time about 30 seconds, using a 60 watt lamp at 36″ distance. (Exposure times will vary depending on density of the positive or tone of the copy).

Increased contrast can be obtained by turning screen film over so that the emulsion side is away from negative. Screen films for different contrasts can also be obtained by using flat or contrasty developers in their production.

IMPROVISED PROCEDURE IN FIELD OPERATION. (See also Paragraphs 49-52.)

Temperature control of the developing, washing and fixing solutions are essential to good negative production, if fogging, graininess, reticulation, and separation of the gelatine emulsion from its base are to be countered. Where control equipment is not available or inoperative, improvised heating with hot water or an immersion heater, or cooling by the addition of ice to the wash water tank to bring the temperature to 65°F, with constant agitation of the solutions, and the possible assistance of film hardners or tropical developer, may be necessary to obtain satisfactory negatives.

Negative materials may often be improvised as in using a process film for continuous tone work (see Formulae) or conversely in using a continuous tone negative for line or halftone work in conjunction with a high contrast developer. Likewise fogged or exposed negatives can be revived when satisfactory material is not available.

A breakdown of equipment may necessitate improvising camera lights or using daylight with prolonged exposures on the camera. Contact negatives can be made in the camera copyboard or on the vacuum back by superimposing a larger sheet of acetate or cellophane to provide vacuum contact. Cameras and enlargers are subject to external vibration, and undue movement or shock should be avoided during exposures if fine detail is to be retained on the negative.

18.—NEGATIVE DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Will not develop	Negative not exposed	Check lens, shutter, and camera lamps for failure to operate properly.
	Developer oxidized	Due to age, or impurities in water. Replace with fresh developer.
	Developer too cold	If temperature is too low, developer will not function. Heat to 65°F.
Develops too slowly	Negative underexposed	Check coverage of arc lamps, lens diaphragm opening, and allow for filter factor, color of copy background, as well as halftone screen. Increase exposure time, if necessary.
	Developer cold	Increase temperature to 65°F.
	Developer old	Usually evidenced by brown color, and slow action on over-exposed test strip. Drain developer, clean tank, and replace with fresh developer. If developer ages too quickly water may be the cause. When doubtful, use distilled, rain, or boiled water for developer.
Develops too quickly	Overexposed	Check diaphragm stop and position of lamps. Correct contributing condition or reduce exposure time.
	Developer too warm	Lower temperature to 65° F. if possible. Otherwise reduce developing time or develop by inspection. Negative may require hardening to prevent reticulation or frilling.
	Negative fogged	Evidenced by general darkening of negative in unexposed areas. May be due to accidental exposure to light or too much light in darkroom.
		Heat, chemical fumes, and age will also cause fogging. Correct cause or replace negatives Note: A slight fogging can be eliminated with a clearing solution, following fixing of the negative.

NEGATIVE DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Will not clear in fixer or clears very slowly	Fixer old or spent	Developing solution carried into the fixing bath by insufficient rinsing of the negative will shorten life of fixer. Drain fixer, clean tank, replace with fresh solution.
Negative veiled or fogged in "clear" areas	General	The use of a clearing bath (Farmer's reducer) will frequently render fogged, overexposed or overdeveloped negatives satisfactory for use. It is also recommended for clearing all halftone negatives developed under conditions contributing to fog.
	Overexposure	Reduce exposure so that image first appears in required time (30-45 sec. for Kodalith film at 65°F)
	Overdevelopment	Develop only for required time. Reduce time for temperatures above 65°F., or develop by inspection.
	Developer old	Requiring prolonged development. Replace developer
	Poor copy	Black lines or type on copy are grey or broken. Slight underexposure sometimes helpful. Clear after fixing.
	Light reflection from arcs into lens.	Adjust lights so that they do not reflect directly from the copyboard glass into the lens.
	Dust or smoke	In the air or on the copyboard glass. Keep room well ventilated and copy board glass clean.
	Dirty lens	Clean carefully by breathing on lens and wiping with lens tissue.
	Negatives old or fogged	Due to age, heat, chemical fumes, too much light in darkroom, unsafe storage facilities, etc., Correct cause. If fogging is slight, use clearing bath after fixing. If serious, replace negatives. If no other negatives are available, reactivate emulsion (see formulae).
Negative not developed uniformly.	Tray development	Negative must be immersed into developer quickly, and tray rocked during development.

NEGATIVE DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Negative not developed uniformly (cont.)	Tank development	Developer in tank must be agitated frequently to prevent denser solutions and colder developer from stratifying or settling to bottom.
Negative grained or reticulated	Solutions too warm	Developer, water, and fixing baths must be at same temperature to prevent reticulation. If temperature is above 80° a hardener or tropical developer is required for some films.
Lacks density	Underexposed or under developed	See "Develops too slowly" above
Lacks density in corners	Illumination not uniform	Usually due to falling off of light intensity on corners of large copy. Increase distance of lights to copy, or use diffusers, or improvise large white cardboard reflectors below and above copyboard to reflect light on to edges of copy. May also be due to exposure with lens wide open. Stop down to F/22 or F/32 for line shots.
Blurred image	Out of focus	Check on ground glass. Ascertain whether copyboard, ground glass and vacuum back were locked in exposure position. Also check scale readings if camera was positioned to scale. In critical focusing, check with lens stopped down to that required for exposure, as focal length may vary with diaphragm opening. When using filters or screen, focus with filter or screen in position. If focal length of lens appears to have altered, have qualified operator check inner and outer elements to make certain they have not loosened.
	Movement	Vibration transmitted to camera may blur fine detail. Reduce movement around camera to minimum during exposure time. Other causes are expansion of copy due to heat from arc lamps in prolonged exposures, shift of lensboard in changing stops, or slippage or lifting of negative on vacuum back.

19.—SUMMARY OF CAMERA OPERATIONS

1. Clean utensils, prepare solutions.
2. Clean and lubricate camera.
3. Check copy for defects and requirements.

3a. (Halftone only) Check tone range of copy for determining required exposures.

4. Mount copy in copyboard.

4a. (Halftone only) Mount halftone screen in screen housing.

4b. (Halftone only) Adjust screen to required screen distance at each corner (13/64 for 133 line).

5. Adjust camera lamps and carbons to obtain a uniform and definite light intensity.
6. Position copyboard and lensboard to ratio of reproduction required.
7. Turn on camera arc lamps and examine image on ground glass. Center image, check size and focus, and adjust if necessary.
8. Stop down lens to value required for camera extension.

8a. (For Halftone) Stop lens down to "highlight stop" (F/22 line).

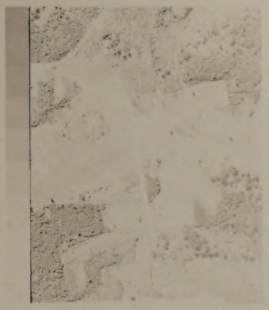
9. Reduce dark room lighting to that safe for the negative material used.
10. Expose and develop test strip at beginning of day's operations, or for uncertain copy.
11. Mount negative of required size on vacuum back.
12. Expose negative.

12a. (For Halftone) Proceed with:

"Highlight" exposure (F/22 line) for required time
"Detail" " (F/45 line) " " "
"Flash" " (F90) for required time (with sheet of white paper covering copy)

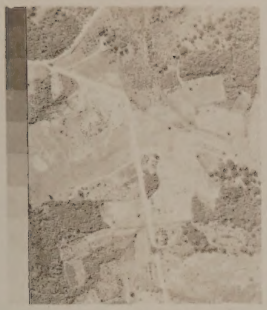
13. Remove negative from Vacuum Back and mount in film frame (or place in tray)
14. Develop negative in tank or tray for required time.
15. Remove negative from developer and lower into wash tank.
16. Remove negative from wash tank and place into fixing tank.
17. Return to washing tank, then examine negative for fog.
18. Clear if necessary.
19. Return negative to wash tank for thorough washing.
20. Hang negative and dry.

FIGURE 12



I (1-3)

F/22 - 40 Sec.
F/45 - 10 Sec.
F/90 - 11 Sec.(Flash)



II (1-5)

F/22 - 50 Sec.
F/45 - 20 Sec.
F/90 - 11 Sec.(Flash)

III (1-7)

F/22 - 65 Sec.
F/45 - 150 Sec.
F/90 - 16 Sec.(Flash)

IV Normal (1-10)

F/22 - 65 Sec.
F/45 - 210 Sec.
F/90 - 18 Sec.(Flash)

V Contrasty (1-10)

F/22 - 40 Sec.
F/45 - 300 Sec.
F/90 - 35 Sec.(Flash)

VI (3-5)

F/22 - 65 Sec.
F/45 - 15 Sec.
F/90 - 13 Sec.(Flash)

Standard Gray Scale

VII (3-7)

F/22 - 90 Sec.
F/45 - 105 Sec.
F/90 - 16 Sec.(Flash)

VIII (5-7)

F/22 - 105 Sec.
F/45 - 135 Sec.
F/90 - 16 Sec.(Flash)

IX (5-10)

F/22 - 220 Sec.
F/45 - 180 Sec.
F/90 - 35 Sec.(Flash)

HALFTONE NEGATIVE CONTROL CHART

133 Line screen - 13/64" Wedge screen separation - 1:1 Reproduction
Light reflective intensity on white area of copy = 225 c/ft.^{2} (Weston Exposure Meter)

Section IV

PLATE GRAINING

	Paragraph
Plate graining equipment	20
Plate graining procedure	21
Summary of operations	22

20. Plate graining equipment. — The satisfactory performance of the zinc plate on the press will be conditioned by the nature of the surface preparations it undergoes to impart it with a clean, uniform, fine, deep grain that will not only be both ink and water receptive, but that will afford a good tooth to which the albumen image can adhere. The grain must also be deep enough to carry the necessary moisture throughout the entire press run and fine enough so as not to break up the edges of the small dots or lines that are exposed upon it. All this can be obtained by proper care and operation in the plate graining procedure.

The plate graining machine (Fig. 13) consists of a stand supporting a heavy tray into which the plates are placed and secured and then covered with graining marbles and an abrasive. The tray is set into an eccentric motion so that the marbles, in rolling in small circles, will gradually grind the abrasive material into the surface of the press plate. The size and kind of marbles, the abrasive material used, and the time allowed for the graining operation will determine the nature of the grain obtained. Marbles that are too light will provide a shallow grain or if too heavy will grind the abrasive itself. Too little water will result in a paste condition of the abrasive that is injurious to itself and to the marbles, while too much water will float the abrasive and prevent its proper graining of the plate. Too slow a speed of oscillation will not permit the marbles to grind the abrasive into the plate, while too fast a speed will cause skidding of the marbles, wearing flats into their surface and scratching the plate. Consequently the importance of a properly balanced condition between all these contributing factors is essential to obtaining the fine, deep, and uniform grain necessary for satisfactory lithographic reproduction.

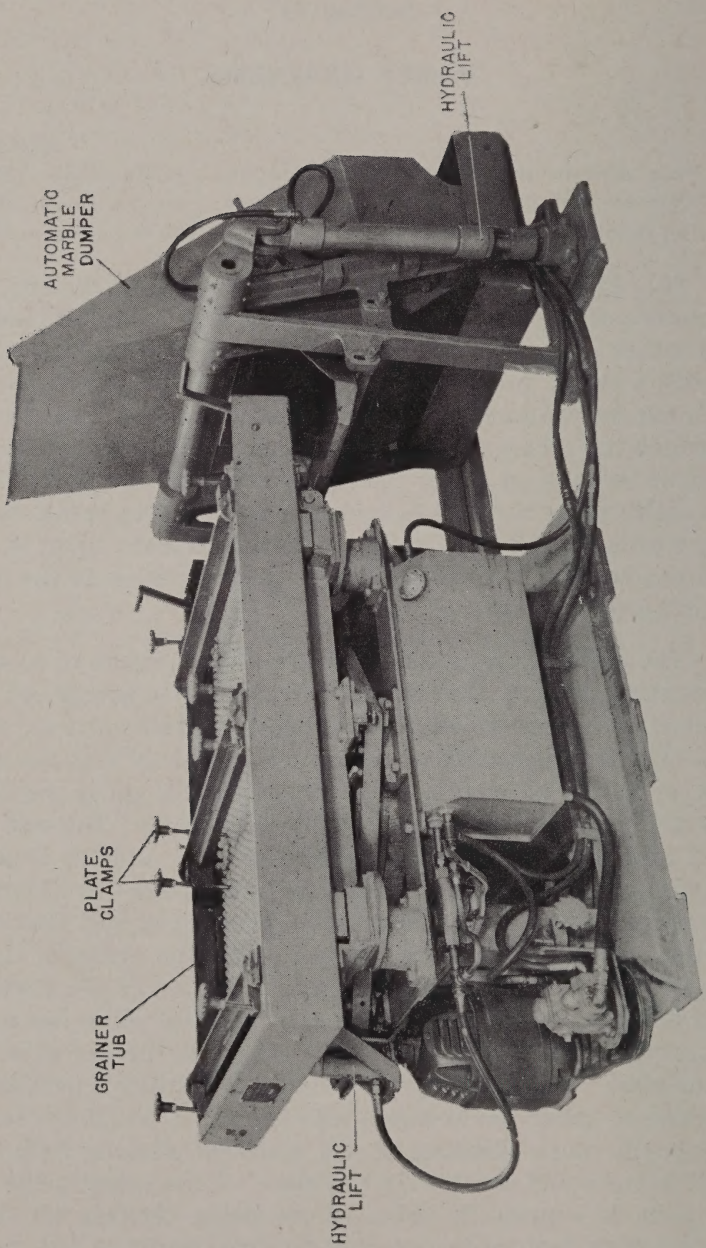


Figure 13. Plate Graining Machine.

Graining marbles are available in steel, glass, porcelain, and wood, in varying sizes from $\frac{3}{8}$" to 1". The usual abrasive materials encountered are flint, quartz, sand, alminum oxide, carborundum, and emery, obtainable in various degrees of coarseness. All can be used to impart satisfactory grains by proper allowances for their nature, but current practice indicates that steel marbles and aluminum oxide abrasive, with a small percentage of tri-sodium phosphate added to the water to reduce rusting of the marbles, are best adapted for the zinc plates used in map reproduction.

The Plate Graining Machine is always located separately from the other equipment as the particles of the abrasive materials used can seriously impare the operation of the press, pumps, and other machinery by working into their bearings and moving parts. This condition is all the more pronounced in the Plate Graining Machine itself, due to its intimate exposure to the abrasive material, and consequently a thorough cleanliness in the graining department and frequent oilng and greasing of the operating parts of the machine are essential to prolonging the life of the equipment.

The steel marbles are also subject to wear, and the smaller and flat ones should be screened out and discarded at regular intervals.

21. Plate graining procedure.— The zinc press-plates furnished to the map reproduction units are ordinarily already grained and must be carefully handled so as to avoid damage or soiling prior to use. A dry place for storage is essential to their remaining in satisfactory condition.

After they have served their purpose, and provided no reruns are expected on the press, they can be reconditioned to form the base for another printing subject. This renewal of the press-plate surface is called Regraining, and is accomplished as follows:

a. Clean and lubricate the Plate Graining Machine before starting it into operation. If marbles are rusted place them in the graining machine on some discarded plates, add some abrasive, tri-sodium phosphate, and water, and run the machine sufficiently to remove the rust. Then wash marbles and the machine thoroughly to remove the rust particles.

b. Straighten the bent edges of the plate, utilizing the steel hand roller, and a mallet if necessary, at all times observing care in handling the plate so that no kinks or severe bends

occur in the effective printing areas. (If the plate shows severe oxidation or is injured to the extent that it cannot be satisfactorily used on the press, it should be discarded.)

c. Wash any remaining ink off the plate, by pouring a small pool of turpentine or gasoline on its center, and then quickly spreading and wiping the surface with a rag ball.

d. Next place the plate in the sink, and wash thoroughly with water and a scrubbing brush to remove the gum. Then drain and place the plate, while still wet, grained side upward, on the bed on the graining machine. If two plates are to be grained at the same time, the ink should be removed from both, and the plates successively washed with water so that the first is not allowed to dry before the second is ready for the grainer.

e. Clamp the plate or plates on to the bed of the graining machine, to secure them against movement.

f. Pour the steel marbles carefully onto the plate in sufficient quantity to form a single layer over its surface, avoiding dropping them from too great a height so that they dent the plate.

g. Weigh out a half pound of the Aluminum Oxide abrasive material, pour it into the measuring cup, marking the cup so that future weighing of the Aluminum Oxide will not be necessary, and scatter it over the marbles. Then sprinkle the marbles with one quart of water into which one ounce of tri-sodium phosphate has been dissolved (mark the small measuring cup to indicate the quantity required to make up one ounce.) (Quantities of abrasive and phosphate are based on 10 sq. ft. grainer area. Amount for other sizes in proportion) The nature of the abrasive, marbles, etc., may necessitate a slight variation in the amount of abrasives and water used. As too little water will form a paste of the abrasive, while too much will float it, the quantity of water used should be just sufficient to cause the abrasive to adhere to the marbles as a thin film.

h. Start the graining machine, and continue the graining operation for twenty to thirty minutes, as required, depending on whether the plate is new or used and the nature of grain desired.

i. Release the plate clamps and carefully draw the plates free while the grainer is in motion. Then place the plate in the sink and flush well with water using a clean scrubbing

brush, reserved for this purpose only, for removing the remaining abrasive material on the plate.

j. Drain the plate, wipe off excess moisture along edges with a clean damp rag and dry quickly with the assistance of an electric fan, or in a heated drying cabinet, as slow drying will injuriously oxidize the plate surface. If the climate is excessively damp or cold so as to subject the plate to condensation of moisture, or if the plates are to be stored for a period of several weeks or longer before using, the plate should be gummed up immediately after washing. Gumming is accomplished by placing the plate on a clean table, pouring a small pool of fresh gum solution on its center, (prepared in accordance with instructions given in "Par. 32" under Plate Making Formulae), and spreading and rubbing the gum down smoothly and evenly with a damp rag ball. The plate is then placed in front of a fan so that it will dry quickly.

k. Wipe the back of the plate clean and dry, then hang it in a storage vault or pack in cases interleaved with clean unprinted offset, tissue, or newsprint paper, until ready for use.

l. Wash out the grainer, and repeat the operations for the next batch of plates.

m. When materials other than Aluminum Oxide 220 are used, as may be required for finer or coarser grains or necessitated by the use of improvised materials, the graining practice will have to be modified to accord with the materials used. An increased quantity of abrasive and graining time is ordinarily required for quartz or sand and it is usually necessary to add a second sprinkling of the sand or grit about five minutes before the completion of the graining operation, to assure obtain a uniformly fine deep grain.

n. At the completion of the graining period, after the grainer and marbles have been washed, the marbles should be removed to their storage bins and fanned dry to reduce their possibility of rusting.

Note: Field conditions may necessitate modifying the graining procedure when normal supplies are unprocurable. Screened and washed sand, carborundum, or granulated flint or quartz may be satisfactorily utilized in such instances.

Chemical removal of the old "work" on the plate by scrubbing with a strong lye (caustic soda) or tri-sodium phosphate solution, or with "chlorox" (5% Sodium Hypochlorite solu-

tion), followed by a cleansing with a brush, a thorough washing with water, and rapid drying, will frequently recondition plates suitable for re-use when normal graining facilities are inoperative.

22. Summary of plate graining operations.—

SUMMARY OF PLATE GRAINING OPERATIONS

1. Clean and lubricate graining machine.
2. Wash ink off plates with turpentine or gasoline.
3. Place plate in sink and scrub well with brush and water.
4. Mount plates on bed of graining machine.
5. Carefully pour sufficient marbles over plates to cover bed of machine.
6. Sprinkle required quantity of abrasive over marbles and the corresponding quantity of water (with tri-sodium phosphate).
7. Start machine into operation and continue for required time.
8. Remove plates carefully while machines are running.
9. Wash plate with clean brush and water to remove abrasive from grain.
10. Drain plate, and dry quickly with fan or in hot box. (If plate is not to be used for some time, it should be gummed with a thin uniform application of gum arabic solution and then dried.)
11. Interleave finished plates with clean offset or tissue paper and store in dry place.

Section V

OFFSET PLATE MAKING

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23. Negative corrections and layouts.— The offset printing plate, unlike the relief blocks, cuts, and type used in letterpress printing, offers very little latitude for corrections or changes, aside from the occasional addition or deletion of prominent markings, and as the exposed subjects cannot be shifted with respect to each other, or other alterations made without injurious effects to the grained surface of the plate, all changes, additions, and positioning for layout must be carried out in the preparation of the original copy, or in the retouching and assembling of the negatives.

Such corrections are most easily accomplished on the original copy, and where possible, the copy should be a clean-cut presentation of the printed sheet desired. However, this condition is not always readily attainable and the use of less satisfactory copy, plus the certain amount of minor defects likely to occur in the exposure and processing stages, will necessitate adding most of the corrections to the negatives themselves. These corrections and additions will consist primarily of the assembly, masking, opaquing, and spotting-out operations, and may also include major changes involving stripping, engraving, and etching of the negative.

a. Layout.— One of the important elements of good printing is obtaining proper layout. This consists of the orderly and pleasing assembly of type matter and pictorial detail among themselves and also in their grouping together on the sheet of paper. Such an assembly involves the mechanical considerations of location of the subjects, folds, backing, cutting, and balance, as well as the more indefinite artistic conceptions known as good form.

The mechanical essentials of the layout can be readily mastered by recognizing the press limitations of maximum printing area, gripper distance, direction of paper grain, and balance of subjects for uniform ink distribution, as well as those of folding, cutting, and trimming, and alignment in backing when printing on both sides of the sheet. The usual procedure is to accurately draw a full scale presentation of the location of the various subjects on the printed sheet, and then to prepare the copy and the negatives to conform with this layout.

In map reproduction where a single subject covers the entire sheet, the handling of the layout is simplified, requiring only proper location and exact dimensions in its preparation.

Layout forms are designated as simple, combination, and step-and-repeat to define that either a single subject, a group of different ones, or a multiple of the same subject are used to compose the printing area of the press-plate. All three forms are similar in preparation, varying only in the recognition given to the means of locating the subjects composing them. The layout may be made directly on the plate, but is more frequently prepared on a heavy orange (80#) masking paper, on which the film negatives can be assembled and attached in position to the indicating center or corner lines drawn thereon. The paper is then cut away in the areas over the printing subjects to permit proper exposure through the negative to the press-plate.
of:

The procedure in the preparation of a layout will consist of:

a. Select a sheet of masking paper large enough to cover the press-plate.

b. Attach the masking paper squarely on the glass top layout table with tabs of self-adhesive tape.

c. With the aid of a sharp pencil or ruling pen, carefully draw lines indicating the vertical center line of the plate, the gripper edge (preferably the bottom edge of the masking paper,, the gripper distance, (corresponding to the margin of the plate necessary for clamping in the press less the distance allowed for gripping the paper and plus whatever paper margin is required), and the positions for the negative or negatives themselves, being guided in this by the location of the center or corner marks exposed on the negatives from the copy. (In combination forms, this layout must be prepared in reversed direction, reading from right to left, as the assembled negatives are turned over on their face when exposing to the press-plate.) (See Fig. 14)

d. Carefully position each negative (emulsion side up) in exact agreement with the locating lines drawn on the layout paper and attach in position with tabs of the cellophane self-adhesive tape.

e. Detach the layout paper with its assembled negatives from the layout table, turn the assembly over on its face, switch on the lights in the table, and using a sharp knife or razor blade, cut lightly through the masking paper (but not the negative) to remove the paper covering the printing areas

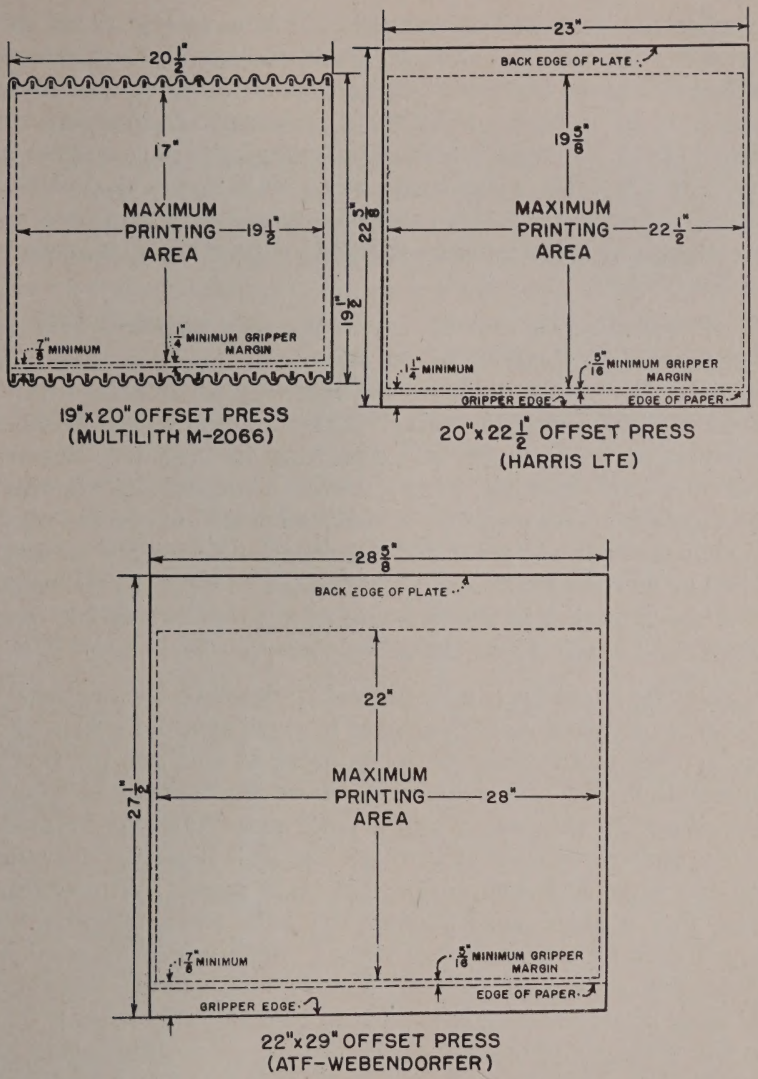

Figure 14. Press-plate Layouts.

of the negative. (A small sheet of celluloid or clear film inserted between the negative and paper will be found helpful to prevent cutting through).

f. With the aid of a retouching brush and opaque, spot out all pinholes and defects due to dust or other agents.

K. The preparation of combination and step-and-repeat forms will follow the same sequence of operations, varying only in that a number of negatives are assembled on the lay-

out sheet and exposed as one unit. It is consequently of importance that each individual negative be equally transparent in the clear areas and correctly exposed, if a uniform printing plate is to be obtained. While it is possible to compensate for variations in the negatives by local dodging, using a sheet of paper or a reading glass to decrease or increase the relative exposure to the press-plate in these areas, such practices are at best a guess and should be avoided by insisting on uniformly good negatives.

Step-and-repeat forms are frequently exposed from a single negative, instead of an assembled group of identical negatives, by preparing a layout carrying the required number of centerlines and openings corresponding to the number of exposures to be made, and attaching the negative in position over each opening, in turn, while masking out all other openings for the exposure. In more advanced work, the preparation of step-and-repeat and combination forms are accomplished by use of a Photo-composing Machine whereby the negatives are mounted in holders and accurately exposed to predetermined locations on the press-plate.

Double shooting is a term used to describe the successive exposure of two or more negatives in exact register over a particular area of the press-plate, in order to combine the printing detail of each and so avoid the more troublesome stripping operation. In this way a single color map plate can be made by successively exposing through the first negative carrying the line work, a second adding the place names and marginal data, and a third contributing the tint areas representing woods, contours, or bodies of water. Such negatives must be of identical scale, and registration between them can be simply obtained by positioning each in turn to engraved center marks on the plate, or by locally developing up the centermarks of the first exposure to guide the positioning of the subsequent negatives.

Stripping is the combination of several negatives to form a single unit. While the term may apply to cutting and joining together film negatives with cellophane self-adhesive tape, stripping is more generally understood to describe the cementing of thin negative films (strip film) in position on the clear areas of the base negative, or the assembly of patches of the strip film in position on a blue-printed key outline glass plate or film. The thin delicate nature of the strip film and the care-

ful handling required in positioning and attaching it to the base negative, makes preferable the alternative method of double shooting, or film negative assembly, if at all possible.

Etching describes two methods of cutting into the negative (or plate), the mechanical one in which a sharpened needle or scraper is used to engrave away portions of the emulsion, as in adding borders or grid lines on a negative or in touching up letters or markings clouded up by local fog or halation, and the chemical etching, in which a controlled reduction of the negative density takes place. Chemical etching in its simplest form is that of an over-all reducer (Farmer's reducer) used in clearing up a fogged negative, and is a useful treatment for converting uncertain veiled negatives into satisfactory ones, especially in line and halftone work. The same solutions used for over-all clearing can be used for local reduction of the denser areas of a negative, or for cutting down a denser print in a mosaic to obtain a uniform tone, by carefully applying with a camels hair brush or tuft of cotton, preferably while the negative or print is wet, and working the solution around constantly, washing away, and reapplying, to avoid sharp demarkation lines at the edges of the solution. In a more advanced form, the application of an asphaltum resist coating is used to protect local areas, so that staging of the negative can be carried out, as is required for color correction in process work.

In the line and halftone negatives used in map reproduction the negative and the surrounding masking serves as a light stencil in permitting the passage of light only through those areas that carry the printing design. Consequently, it is essential that the opaque portions of the negative and masking be completely opaque to the light affecting the albumen sensitizer. As the effective or actinic light is largely in the blue, violet and ultraviolet regions of the spectrum, it is feasible to use orange, red, or black masking, for all of these colors will prevent passage of the actinic light. In addition it is equally important that the emulsion face of the negative shall be in perfect contact with the press-plate, especially in the vicinity of halftones and fine map detail. Thick masking, or opaquing, on either side of the negative, may result in out-of-contact areas that will lack sharpness of detail, and tend to "fill in" on the press so that halftones will print a darker tone or even a solid mass of ink. Since masking is generally used, it is desirable that it be kept as thin as possible by cutting it

from a single sheet of masking paper, avoiding overlapping of paper and tape, and confining the masking to the back of the negative as much as is feasible.

A good line or halftone negative will have clear transparent areas to represent the printing subject and dense opaque areas constituting the non-printing portions. If a veil or fog is evident when the negative is placed against a white sheet of paper, under-exposure of the press-plate and poor printing results may be the consenquences. If time permits, especially before opaquing and masking have been added, the negative should be returned to the camera department for clearing. Otherwise prolonged and uncertain exposures will be necessary to obtain a sufficiently light-hardened albumen image, with the possible associated danger of "printing through" the opaque areas of the negative and surrounding masking, so that a tint or scum appears on the "non-printing" portions of the plate. The negative should also carry corner and center marks so that these will be printed through on the plate margins to subsequently enable the pressman to definitely locate the plate on the press cylinder for correct position and color register.

24. Plate making.— *General.* The offset press plate consists of a light gauge sheet metal or plastic plate whose surface has been treated to make it suitable for the lithographic process of printing. It is essentially a planographic plate depending upon the mutual repulsion between water and grease to define its printing areas, and must accordingly be a clean cut presentation of the form to be reproduced on the sheet of paper. It must also be capable of retaining the printing image throughout the required run on the press without loss of detail and without acquiring ink in the surrounding areas to tint the clear portions of the paper. Inasmuch as the offset or indirect principle of transferring the ink from the plate to the paper is used, the subject matter on the plate must read correctly, i.e. from left to right, exactly as it will appear on the paper.

The preparation of the photo-offset press plate requires that it be cleaned, sensitized, exposed, developed, and treated to make it ready for the press. Several units of equipment are necessary to accomplish this procedure and consist essentially of a sink or trough to clean and develop the plate; a coating machine to sensitize its surface; a layout table to prepare the negatives for exposure on to the plate; a vacuum

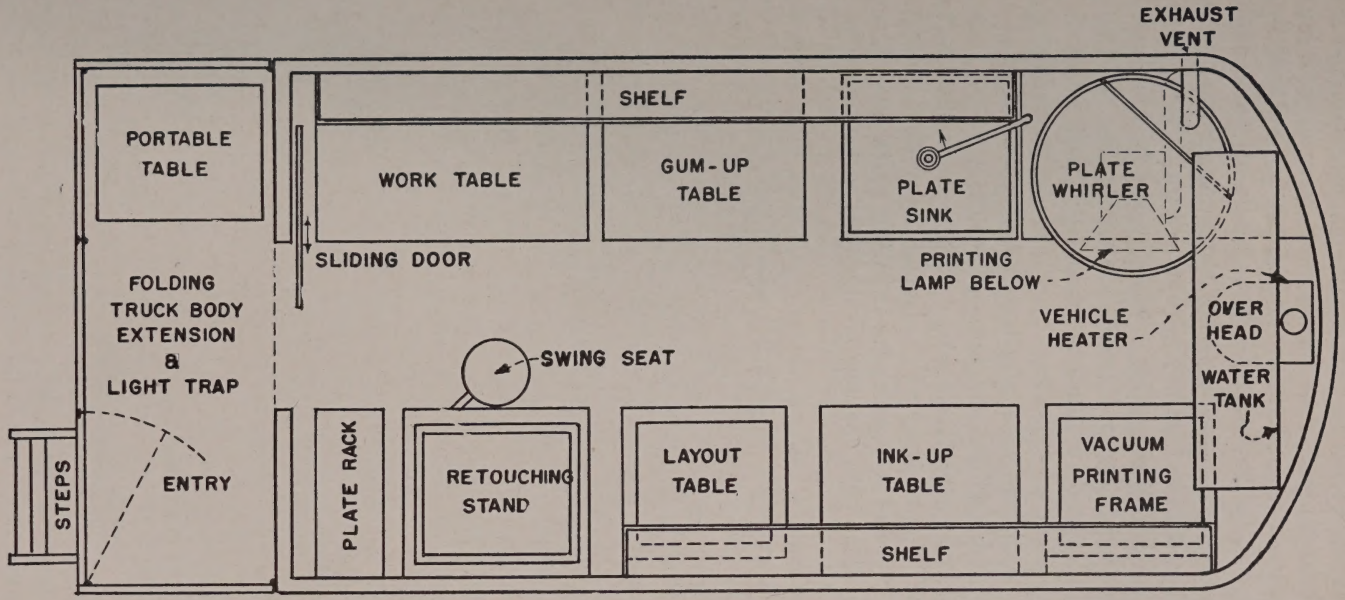

Figure 15. Mobile Plate Processing Unit.

printing frame with an arc lamp to consummate the exposure; and several tables for inking, gumming, or adding hand work to the plate. (See Fig. 15) The essential units of equipment are more fully described in the following paragraphs.

25. Plate coating machine.— The plate coating machine, or whirler, is required for applying a uniform coating of the sensitizing solution on the press-plate. It consists of a plate-carrying member contained in a housing, that can be rotated at varying speeds usually ranging between 30 and 90 revolutions per minute. Electrical heating units and an air circulating system are normally incorporated to assist in the drying of the sensitized coating. (Fig. 16)

The light sensitive coating on the press-plate is the foundation of the printing areas, and in order that uniform printing quality and a dependable printing plate be obtained, it is essential that this coating be uniformly deposited in as thin

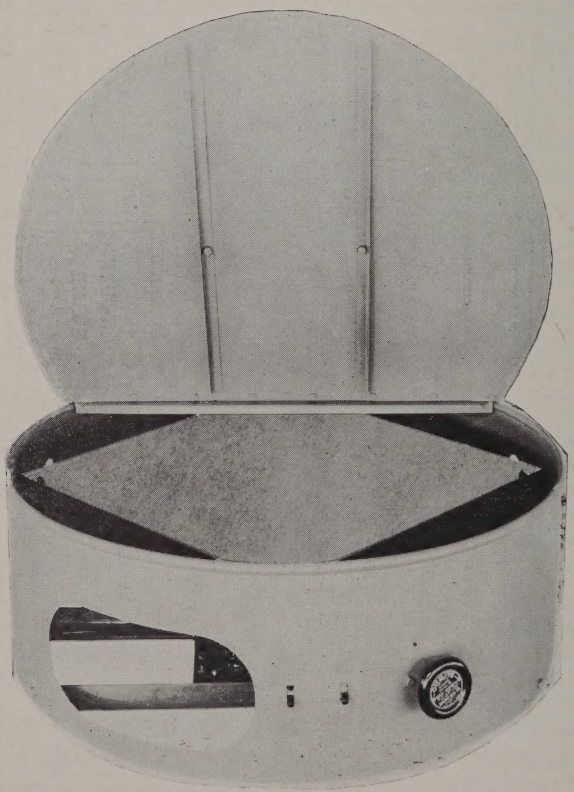

Figure 16. Plate Coating Machine.

a layer as can be subsequently processed without difficulty. A thick coating is not only subject to mechanical abrasion, but will absorb water and other chemicals on the press resulting in poor printing quality and erosion or "walking away" of the work areas. Cleanliness in coating is also essential, as dust or bubbles will result in defective printing areas.

The plate coating machine is constantly exposed to water and chemical solutions, and regular lubrication of all bearings is essential in preventing their rusting and "freezing" up. It is also important that the interior of the tank be kept clean by a through washing with water at the conclusion of each day of operation, to avoid the consequences of dried solution on the interior of the tank scaling off, and settling on to the sensitized coating of the press-plate.

26. Vacuum printing frame.— The vacuum printing frame is required to bring the surfaces of the negative and the press-plate into intimate contact so that exposure to the arc lamp can be made without danger of "undercutting" beneath the opaque areas of the negative with its consequent spreading or thickening of the printing detail. It consists essentially of two frames supported on a stand, and hinged or elevated so that they can be separated or brought together as required. The upper frame usually carries a plate of clear glass, and the lower has a rubber blanket bordered by a rubber sealing ring. The blanket contains an outlet fitting that is connected through a rubber hose to the vacuum pump. In operation, the sensitized press-plate is placed on the bed of the lower frame. The negative with its mask, (consisting of an opaque paper border or layout sheet used in locating the negative on the plate and also in preventing the light from exposing the non-printing areas surrounding the negative) is then superimposed in position on the plate, with additional masking added where necessary, and the two frames locked together. The vacuum pump is turned on to exhaust the air between the frames, allowing the external air pressure to force the blanket into contact with the plate glass, in this way also squeezing the press-plate and negative into contact. (Fig. 17)

Care of the vacuum frame is a simple matter requiring only proper lubrication of the vacuum pump and motor, and keeping the plate glass clean. A soft rag with a suitable solvent is used to clean the glass and any material that may

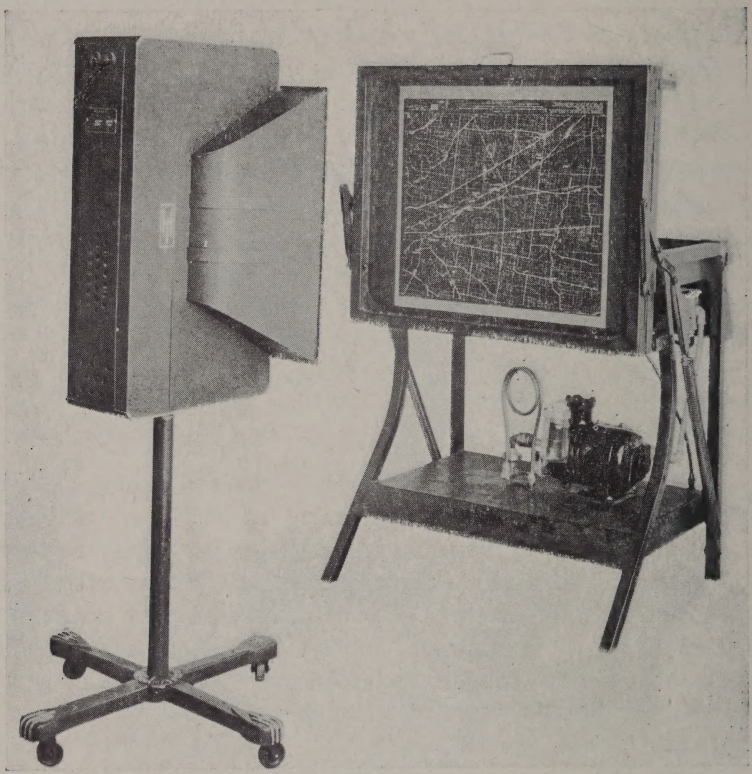

Figure 17. Exposing Press Plate.

scratch or injure its surface is avoided, as such scratches will leave their shadow imprints on every press-plate made.

The maximum pressure that can be obtained with a vacuum frame is approximately 15 pounds per square inch. This deserves consideration in two respects. It means that the total pressure between the blanket and the plate glass in a 24 x 26″ vacuum frame is about five tons, and when glass negatives are used, any particles of dirt or heavy masking between it and the plate glass may result in breakage of one of them. On the other hand, fifteen pounds per square inch pressure is insufficient to force the press-plate into contact with the negative in areas close to heavy masking or opaquing, and care should accordingly be taken to keep the masking as thin as possible. In normal operation, about 20″ of vacuum (10 lbs. per square inch) is used as this affords sufficient contact pressure without taxing the vacuum pump too severely.

27. Plate making.— The albumen or direct process of photo-lithography has been adopted for the preparation of offset press plates in the field primarily because of its comparative simplicity, and although better plates can be produced by deep etch or other methods, the additional time and operations involved do not at present justify their adoption for field use. The albumen process utilizes the effect of the exposure to a bright light rendering a dried film of bichromated albumen insoluble in water, to selectively "light harden" only those areas that are to form the printing surface, as is in turn determined by the superimposed negative and masking, so that upon subsequent greasing of the entire albumen coating and immersion in water to dissolve away the unexposed albumen, the grease will remain only on those areas of the plate on which its albumen base still adheres. Inasmuch as the greasy areas of the plate so produced are dependent on the durability of the underlying foundation of albumen, it is essential that this base be rendered thoroughly insoluble in exposure and that it be as thin and uniform as possible.

Although prepared sensitizing solutions may become available, the standard albumen process should nevertheless be mastered as the basis for all similar procedure, and is detailed in the following:

a. Prepare the necessary solutions to clean, sensitize, develop, gum and etch the press plate. (See formulae in paragraph 32.)

b. When all required solutions are available, clean the press-plate by placing it in the sink, flushing it with water and assisting with a scrubbing brush. Then pour about four ounces of the counteretch solution over the plate, spreading it quickly and distributing and scrubbing it evenly for about one minute with the aid of the scrubbing brush. Finally wash the plate thoroughly, first using the scrubbing brush and then flushing with clean water, keeping the plate wet until ready for the coating operation.

c. Prepare a quart graduate of water and about four ounces of sensitizing solution in the pouring container in advance of the coating operation, then remove the press-plate from the sink, and place or mount it centrally in the Plate-coating Machine (Whirler). (The spout of the pouring container can be covered with several layers of dampened cheesecloth tied over its end to prevent the transfer of air bells to

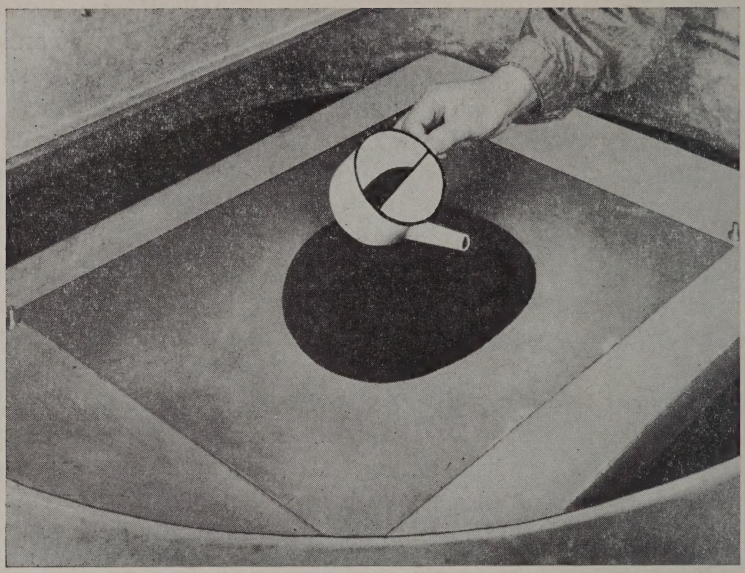

Figure 18. Sensitizing Press Plate in Whirler.

the plate.) Start the whirler revolving at about 35 R.P.M. and pour the quart of water on the plate so as to flush off any accumulated dust. When most of the water has been thrown off the plate with only a few remaining drops dripping from the corners, pour the sensitizing solution in a steady stream on to the center of the plate, continuing the pouring until the expanding circle of solution reaches the inner edges of the plate. After whirling for about half a minute, increase the speed to 60 R.P.M., turn on the heat, close the coater and allow it to spin until the plate is thoroughly dry. (About 7 to 10 minutes.) (Fig. 18.)

d. The plate is now sensitized and all subsequent operations up to the developing step must be carried out in a subdued or amber light.

e. Remove the plate from the whirler, wipe the remaining drops of solution on the back with a dry rag, and place the plate, sensitized side up, on the bed of the vacuum printing frame.

f. Next place the prepared negative with its attached mask on the press-plate so that its emulsion side is in contact with and accurately located to the gripper edge of the plate, as guided by the reference marks appearing on the mask.

g. Check the vacuum frame glass again to make certain that it is clean, using only a soft rag and moisture or a solvent such as gasoline for cleaning, then close the frame, turn the vacuum switch on, and when the dial reaches 20″ of vacuum, tip the frame into vertical or exposing position. The vacuum can be adjusted to more or less than 20″ by means of the escape valve, but 20″ should generally be used with film negatives, increasing it to the maximum obtainable only when thick masking necessitates, and reducing the pressure to about 10 or 12″ when glass negatives are used. (When glass negatives are to be exposed on to press-plates, the areas of the plate not covered by the negative must be filled in with strips of card-board or wallboard of the same thickness as the glass to avoid embossing of the plate.) (Fig. 17)

h. Position the arc lamp centrally facing the vacuum printing frame, locating it so that the carbons are about four feet from the surface of the glass (increase this distance to an amount greater than the diagonal of the plate, for the larger sizes) and mark the floor under the center of the arc lamp stand to permit its being readily repositioned to the same location for all future plates. Then insert or check the carbons so that they meet centrally and can be separated by at least 1½″ when spreading the arms.

i. The exposure time must be determined experimentally at first, but once obtained, a systematic control can be established for all future plates, depending largely upon the relative humidity in the plate processing unit. To determine the necessary exposure time, a small negative, containing fine line or halftone work, should be printed in six positions on the press-plate, starting with 1½ minutes exposure at one corner, after first masking out the rest of the plate, then increasing the exposure time on each successive location by ½ minute, with a corresponding shift of the masking, until six prints have been made on the plate representing exposures ranging from 1½ to 4 minutes in ½ minute intervals. The plate is then developed as described in the following steps, and finally examined under a magnifying glass. The correct exposure time should show a dot or detail size equal to the corresponding detail in the negative. If the entire plate develops out too easily in the unexposed areas, too thick a coating is indicated, and a new plate should be made by increasing the coating speed to 65 or 70 R.P.M. as required. If the development in the unexposed areas occurs with difficulty, necessi-

tating prolonged soaking in water and the addition of ammonia, too thin a coating (or light fog) is usually the cause, and a slower coater speed should be used. A correctly coated and exposed albumen plate will not develop too easily, but will require some soaking and the possible assistance of the sodium bicarbonate solution when halftones or fine line areas are encountered.

j. Assuming that the correct exposure time has been determined to be 3 minutes at 40% relative humidity, and 60 R.P.M. coater speed, prepare a chart using data accumulated over a period of weeks or months showing the corresponding exposures for each ten percent change of relative humidity, where a 10% increase of humidity will represent a proportional decrease in exposure, and conversely with reductions, as shown in any one of the vertical columns on the next page. Only one of the vertical exposure columns or an experimentally determined one will be needed. If a dial type relative humidity gauge is available, the exposures can be marked on a paper attached to its face so that the pointer will directly indicate the required exposure time.

Proper exposure control can then be maintained, and regular press-plate production undertaken by continuing as follows:

k. Having determined the correct exposure, and established a system for its control, the press-plate will be cleaned, counteretched, and coated as described in steps 27b. to 27h., and then exposed to the arc lamp for the required time in accordance with the relative humidity indicated. Where a relative humidity gauge is not available, some control over exposure time can be maintained based on the time required for the previous plate, with such compensations as are indicated necessary by the relative ease or difficulty in development of the plate.

l. The Vacuum Frame is then tilted back into horizontal position, the vacuum pump stopped (after first opening the air escape valve so that back pressure cannot develop in the pump to force the oil out into the vacuum line), and the negative and press-plate removed from the vacuum frame. The negative is returned to the container from which it was obtained, and the press-plate placed on a dry table for application of the developing ink.

m. Apply the developing ink by pouring a small pool, about two inches in diameter, on to the center of the plate,

RELATIVE HUMIDITY	CORRESPONDING EXPOSURE TIMES (approximate)									PROPORTIONAL DECREASE TO NEXT STEP	PROPORTIONAL INCREASE TO NEXT STEP
20	3′ 0″	3′23″	3′45″	4′ 8″	4′30″	4′53″	5′15″	5′38″	6′ 0″	1/3	1
30	2′ 0″	2′15″	2′30″	2′45″	3′ 0″	3′15″	3′30″	3′45″	4′ 0″	1/4	1/2
40	1′30″	1′41″	1′53″	2′ 4″	2′15″	2′26″	2′38″	2′49″	3′ 0″	1/5	1/3
50	1′12″	1′21″	1′30″	1′39″	1′48″	1′57″	2′ 6″	2′15″	2′24″	1/6	1/4
60	1′ 0″	1′ 8″	1′15″	1′23″	1′30″	1′38″	1′45″	1′53″	2′ 0″	1/7	1/5
70	51″	58″	1′ 4″	1′11″	1′17″	1′24″	1′30″	1′36″	1′42″	1/8	1/6
80	45″	51″	56″	1′ 2″	1′ 8″	1′13″	1′19″	1′25″	1′30″	1/9	1/7
90	40″	45″	50″	55″	1′ 0″	1′ 5″	1′10″	1′15″	1′20″	1/10	1/8

and then using a dry rag ball, quickly distribute the ink uniformly over the plate, and rub down evenly and smoothly with another dry rag ball. Fan the plate dry for about a minute. (If the developing ink is too thick due to evaporation of the solvent, and cannot be applied smoothly, it can be diluted with a small quantity of spirits of turpentine.)

n. Plug the sink drain or use a tray, and pour in water until the bottom is covered to a depth of about one inch. Then place the inked and dried plate into the water and allow it to soak for one or two minutes until a swab of cotton rubbed lightly in a circle will start to develop up the image. Continue the development, turning the cotton as the development progresses, and changing it as it collects ink, until the entire plate is developed out clean. A short circular stroke without pressure and continued progressively over the surface of the plate is the best procedure to follow. In the shadow tints of halftones, or in fine line work where the detail tends to be joined together by the film of developing ink, as may be evidenced by examination under a magnifying glass, the cotton should be dipped into the sodium bicarbonate solution to assist the removal of the excess ink, draining the water out of the sink or tray if necessary to avoid excessive dilution of the bicarbonate solution. Under extreme conditions, when the sodium bicarbonate solution does not prove effective, a solution of ammonia (1 oz. to 1 qt. of water) can be used to complete the development though this is usually an indication of overexposure, light fog, too thin or old a coating, or a poor negative, and the condition should be corrected when making the next plate. After the development has been completed, the plate is flushed with clean water and finally drained or squeegeed off.

o. While the plate is still damp, apply the plate etch to its surface with the camel's hair etching brush, circulating the etching solution quickly and uniformly with horizontal and vertical strokes, and continue spreading for about one minute, (or longer if difficulty in development was experienced). Then flush again with water, squeegee off, and remove plate to a dry table.

p. Pour a small pool of gum arabic solution on to the center of the plate (about two inches in diameter), and then using a damp rag ball, spread the gum over the press-plate in both directions. Finally turn the rag and rub down smoothly so that a thin even coating of gum covers the plate. Then fan

dry. Gum streaks across printing areas usually indicate that the gum has not been rubbed down uniformly and thin enough and a further rub down with the damp rag ball over the entire plate should be carried out.

q. If the plate is to be used immediately, it can now be sent to the press, but if a delay of a day or more is at all likely, or if the plate is required for some other color than black, it is advisable to wash it out under asphaltum, as some developing inks contain dryers and may lose their affinity for the offset printing ink. This is accomplished as follows:

r. Place the plate face upward on a dry table, and pour a small quantity of turpentine on the center. Using a dry rag ball, spread the turpentine over the plate so that it dissolves the developing ink, and wipe the plate clean and dry with the rag, making certain that no developing ink remains on the plate. Then pour a small pool of asphaltum on the plate, about two inches in diameter, adding a little turpentine if the asphaltum appears thicker than the developing ink previously used, and selecting a dry area on the rag ball, spread the asphaltum over the plate and rub down smoothly and evenly, as was previously done with the developing ink and gum coatings. The plate may now be stored indefinitely providing it is kept in a dry place.

s. When hand work, such as painting in solid printing areas or ruling lines with tusche is to be added to albumen plates, normal plate procedure is followed up to step 27o, where the counteretch for hand drawn plates (Par. 32) is used in place of the plate etch, and distributed over the surface for about a minute, assisting with a wad of cotton, then flushing well with water and drying quickly under a fan. As the plate is sensitive to grease, it must be handled carefully to avoid the possibility of fingerprints or other marks on its printing area taking ink on the press. Additions or corrections can now be made as described under the procedure for tusching the plate.

28. Tusching on the press-plate.— Tusching is the process of greasing in definite areas of the plate by hand, using a liquid consisting of an emulsified grease or diluted ink that can be applied with an artist's brush, lithographic pen, or ruling pen, similarly to drawing with ink on paper. The cleaned and counter-etched plate, either bare, or with an albumen or blue-print image exposed on it, is sensitive to grease, and should only be handled by the gripper and back edges as finger

marks or any similar accidental marks on the work area of the plate will pick up ink on the press. The drafting of the plate can be facilitated by using an arm rest consisting of a board about ½″ x 6″ x 24″ or longer, having a ¾″ x ¾″ x 6″ block fastened to the underside of each end so that it bridges the plate, or by using pieces of clean blotter or paper as hand rests. Pour a small quantity of tusche in a small deep dish or in an upturned bottle cover, and if it is to be applied to the plate by brush, paint it on in a thin uniform layer, covering the area with one stroke where possible. If the tusche is too thick to flow properly when using a pen, it can be reduced by the addition of water or turpentine, according to the instructions appearing on the bottle, but only sufficiently to flow properly, for excessive thinning will cause the tusche to spread on the plate. It is advisable to try the tusche on the gripper or back edge of the plate before actually drawing in the required work areas. A water emulsion tusche should be allowed to dry for an hour or longer before finishing up the plates. (Developing ink or transfer ink thinned with turpentine to a proper working consistency is an excellent improvised tusche, and similar to crayon or pencil, does not require a long drying period). After the tusche has dried on the plate, it is dusted with French Chalk (Talcum Powder), using a tuft of clean dry cotton for applying the chalk, and avoiding rubbing, as this may spread the tusche into adjoining areas. Then place the plate in the sink, and apply the plate-etch with the camel's hair brush, using light strokes in both directions to distribute the etch evenly as in step (27-o) and continuing the etching operation for about a minute. Flush off the etch with water, drain the plate, place it on the table, and pour a small pool of gum on the center, spreading it and rubbing down thin with a damp rag ball, as is detailed in step (27-p), and fan dry. Finally wash out the plate with turpentine and apply a thin coating of a prepared wash-out solution in the same manner as described under operation (27-r). The plate is then ready for the press, or it may be stored in a dry place until needed.

29. Carbon paper tracings.— Press-plates required for overprinting can frequently be prepared by transferring the additional data drawn on the map directly to the plate through an intermediate sheet of carbon paper placed between the map and the plate. A lithographic carbon paper should be used for this purpose, but if not available, the standard typewriter

carbon paper is a satisfactory substitute. Preparation of the press plate includes washing, then application of the grease sensitizing counteretch, followed by flushing with water, and rapid drying under a fan. As the plate is very sensitive to grease in this condition, it must be handled carefully. In placing the carbon paper, superimposing and attaching the map in position, and tracing the outlines and data, care that pressure is applied by the stylus or pencil only where required, is essential. If the data is to be transmitted to localized areas only, small sheets of carbon paper can be used, but in all instances, corner marks or other reference marks must also be traced to aid in correctly registering the overprint on the maps. Tusching or the application of litho crayon can subsequently be added to the plate to emphasize necessary detail. The plate is then prepared for the press by applying the plate etch, gumming thinly, drying, and then washing out with turpentine and a prepared washout solution as described in paragraph (28) under Tusching the plate.

30. Making blueline (Blue printing the press-plate.)— Bluelines are printed on press-plates (or on lacquered or metal mounted drawing paper) in order to provide an outline to which tusching or other hand work can be added in exact register with the other color plate or plates made from the same master negative. They are of a similar nature to the blue prints used extensively in machine shop work or for architectural purposes, differing only in that they are made on the metal plate rather than a paper base. Ordinarily the negative used for making the black printing plate by the albumen process is also used as the "key" negative for making the blue line exposures for the other color printing plates.

The procedure for making a blue line press plate follows:

a. Clean and counteretch the press plate similarly to preparing for sensitizing with albumen, keeping the plate wet up to the application of the blue print solution.

b. Place or mount the plate centrally in the Plate-Coating Machine, and set into rotation at about 35 R.P.M.

c. Pour the mixed blue print sensitizer (Par. 32) onto the center of the press-plate in sufficient quantity so that in spreading it will cover the plate, then close the coater, turn on the heat, and allow to spin until dry.

d. Remove the plate from the coater, wipe the back dry, and place it on the bed of the vacuum frame.

e. Locate the negative accurately on the press-plate, similarly to that required for albumen plates (27 f.), close the vacuum frame, and start the pump, adjusting the escape valve to 20″ of vacuum for film (or about 10″ for glass negatives), as described in step (27-g), then tilt the vacuum frame into vertical position.

f. Expose the plate to the arc lamp, for about 6 minutes.

g. Remove the plate from the vacuum frame, place it in the sink, flush with water, then apply the grease sensitizing counteretch, and dry quickly. The plate is then ready for tusching and as it is sensitive to grease it must be handled carefully.

h. Blue lines prepared on metal mounted drawing paper, for use as color separation camera copy, are similarly processed with modifications in the materials used. The freshly prepared blue print solution is flowed, or spread over the paper surface with a camel's hair brush, and then dried in a subdued light. Exposure to the arc lamp, with the negative in position in a vacuum frame, accords with paragraphs (e) and (f) above. Development is carried out by swabbing the surface of the paper with a wad of cotton steeped in water, and intensification, if necessary, can be obtained by a subsequent wiping with a weak one or two percent Hydrochloric or Acetic acid, or ammonium bichromate solution, followed by flushing with water and thorough drying. The necessary detail is then drawn on the blue printed paper with india ink. Imprints of titles, nameplaces, or marginal data are then pasted in position (preferably with rubber cement), center and corner or trim marks are added, and the copy finally checked and proof read before sending it to the camera. As the blue outlines can easily be eliminated in the camera, only the inked in and printed detail will be photographed on the negative.

31. Bichromated gum coating for desensitizing plates.— The application of a protective light hardened bichromated gum coating to the non-printing areas of the press plate is frequently helpful in resisting the severe treatment accorded the plate during the preliminary period required in adjusting the press. It further reduces the tendency of the plate to scum or catch up, and if difficulties of this nature are experienced, it is advisable to include the bichromated gum coating operation in making the plate for the added assurance of satisfactory operation that it affords.

The bichromated gum coating solution is obtained by dissolving 50 grains of Ammonium Dichromate in 4 oz. of water, adding this to 8 oz. of the 14° Baumè gum arabic solution, prepared as described in paragraph (32). It is applied to the press plate in place of the regular gum coating, following etching of the plate, and is rubbed down and dried to form a uniform thin coating, free from all evidences of gum streaks. The plate is then exposed to the arc lamp for about the same time as required in making the albumen plate, next washed under water for two or three minutes, and finally gummed up with a uniform thin coating of the regular plate gum arabic solution. If the bichromated gum coating evidences a tendency to scum, over exposure is indicated, and the time for exposure to the arc lamp should be correspondingly reduced.

32. FORMULAE

(1) COUNTERETCH FOR ALBUMEN PLATES:—

Acetic Acid (glacial)	6 oz.
Water	1 gal.

(2) COUNTERETCH FOR HAND DRAWN PLATES:—

Nitric Acid	1 oz.
Alum, (potassium)	4 oz.
Water	1 gal.

(3) ALBUMEN SENSITIZER:—

Solution a.	Albumen (flake or scale)	3 oz.
	Water (to 3.3° Baumé) or	24 oz.
Solution b.	Ammonium dichromate	1 oz.
	Water (to 5.1° Baumé) or	12 oz.
Solution c.	Ammonium Hydroxide	½ oz.
	Water	4 oz.

Dissolve albumen by enclosing in cheesecloth bag suspended in the water. (See Fig. 19)

Add solution a to b. Then add c in sufficient quantity to just clear, (or to reach a pH of 7.6). Filter through a pad of cheesecloth or cotton. Add water, if necessary, to bring the specific gravity of the solution to 1.029 or 4.1° Baumé: Keep sensitizer in a cool dark place. Solution can be used within a few hours after mixing and if kept cool, is satisfactory for several days. The addition of 50 grains of sodium benzoate or 1 dram of Formaline to the albumen (Solution a) will act as a preservative and extend its effective life.

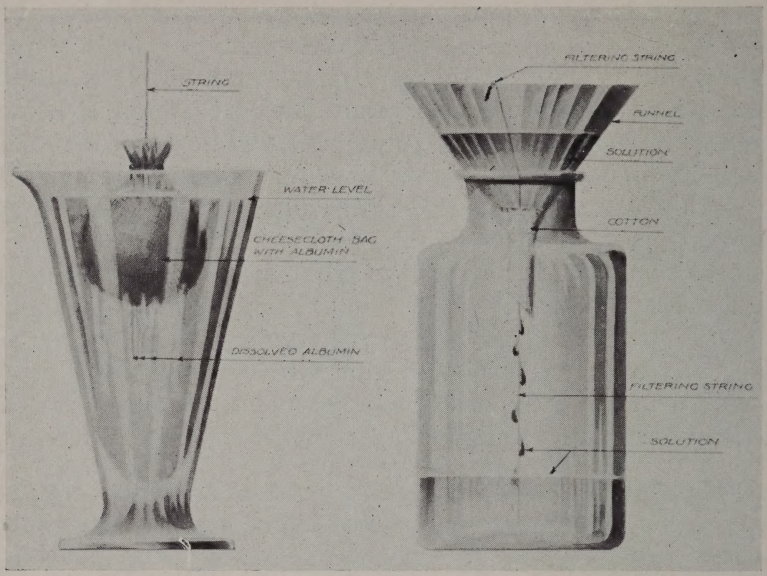

Figure 19. Dissolving and Filtering Albumen Sensitizer.

(4) PLATE ETCH:—

a.	Phosphoric acid (85%)	1 oz.
	Water	2 oz.
b.	Gum Arabic Solution (14° Baumé)	24 oz.
c.	Ammonium Bichromate	¼ oz.
	Water	2 oz.

Dissolve, add together. Keep in cool place. Effective for several days or longer until souring occurs. Useful life can be extended by adding preservative to the gum.

(5) GUM ARABIC SOLUTION:—

Gum Arabic (lumps)	1 lb.
Water (to 14° Baumé) about	32 to 36 oz.

This solution consists of gum arabic dissolved in water by suspending the gum in a cheesecloth bag until the density of the solution reaches 14° Baumé. (Effective life, terminated by souring of the solution, can be extended by addition of a preservative such as ¼ oz. of Formaline or Sodium Benzoate to each 64 oz. of Gum Solution)

(6) SODIUM BICARBONATE SOLUTION (to assist development):—

Sodium Bicarbonate	1 oz.
Water	16 oz.

(7) BLUE PRINT SOLUTION: (for blue printing only):—

Stock a.	Potassium Ferricyanide	2 oz.
	Water	12 oz.
Stock b.	Citrate of Iron & Ammonia (Green Scales)	4 oz.
	Water	12 oz.

Keep in separate bottles in a dark place. Mix equal quantities of Stock *a.* and *b.* just before using. (One ounce of each mixed together is sufficient to coat a plate)

Notes:— The albumen process of plate making involves the use of several critical materials and it may accordingly be necessary to improvise satisfactory substitutes in the field.

Albumen can be replaced with the whites of fresh eggs, glue, casein or the synthetic substitutes procurable commercially. Due allowance for their nature must be made in adjusting the coating and exposure operations to their requirements.

Gum Arabic can be replaced by albumen, glue, starch (dissolved in hot water to form a light paste) or a mixture of these. Satisfactory commercial products are also available.

Humidity variations resulting in shrinkage or stretch of the negatives to the extent that misregister or errors in linear scale will result, can frequently be compensated for by placing the negatives between dampened blotters to expand them, or on a heated light table to contract them into correct size. Such corrections must necessarily be made immediately before exposing the plate to preclude reversal of the negative to its initial condition.

A humid environment may necessitate slower whirler speeds in sensitizing the plate, and with extreme humidities, the use of a plate etch in place of the counteretch may be helpful to reduce scumming and development difficulties. The bichromated gum coating will also be found helpful under these conditions.

Dry climates may require dilution of the sensitizer with water, or increased coating speeds to counteract its faster setting time, as well as an increased exposure time to prevent the dissolving away of the image in development or on the press.

33.—PLATE MAKING DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Plate will not counteretch uniformly	Greasy areas	A more concentrated counteretch may cut through the grease. A lye solution scrubbed over the plate, washed, and then counteretched if greasing is severe. Otherwise return plate to grainer.
Plate coating not uniform	Greasy areas	Will repel coating. Noticeable chiefly on edges of plate where handled. Handle plate by gripper and back edge only so that work area will not be affected.
	Dry areas	Allowing plate to dry locally before coating. Keep plate wet with water until solution is applied.
	Coating thickness not uniform	Results from waves in plate, low side on plate support, or non-uniform pouring. A faster coating speed frequently helpful. If difficulty is experienced in applying uniform coating, pour from center outward in a steady stream so that solution spirals outward on the plate.
Plate coating spotted	Rays	Due to irregular pouring. Pour solution continuously in center outward so that solution spirals outward on plate.
	Comets or flares	Due to bubbles, dirt, or dust on plate or in solution. Wash and scrub plate thoroughly following counteretching, using filtered water or pouring water through a cheesecloth pad to eliminate dirt, sand, and gasses in water. Just before coating, pour a quart of filtered or settled water over plate. When applying sensitizer use freshly filtered solution to remove bubbles and filaments. Pour with spout of container covered with dampened cheesecloth and held close to plate so that bubbles do not form. Keep interior of coater clean, and wet thoroughly prior to coating to settle dust and dried albumen flakes.
Plate does not develop	Plate fogged	Due to excessive exposure to room lighting, or heat in whirler, or aging plate too long before using. Work under diffused or amber light. Correct other causes. In emergency, such a plate can sometimes be developed out by

PLATE MAKING DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Plate does not develop (Cont.)		soaking with a 3% ammonia solution until developing starts, then transfer to water,—but too forced a development may result in a "blind" or scummed plate on the press.
	Coating too thin	Usually associated with high humidity, when most of sensitizer spins off before it can "set" and dry. May be further complicated by use of too greasy a developing ink that penetrates through the coating to the metal itself. A slower coating speed, or a double application of the sensitizer, the second applied immediately after the first, is helpful. If high humidity and temperature are encountered, using a plate etch instead of a counteretch facilitates subsequent development, due to a small amount of gum remaining in the grain of the plate. Assisting development with a 3% bicarbonate of soda or ammonia solution is usually required, if plate is to be saved. If repeatedly encountered use bichromated gum coating after development and etching.
	Sensitizer too old	Effect same as for "Plate fogged" above
Plate develops with difficulty	Same as above	Same as for "Plate does not develop" but conditions, and corresponding treatment are not as severe.
Plate develops with difficulty in well defined areas	Negative lacks density or plate is overexposed	Partial light hardening due to light penetrating through the "opaque" areas of the negative. Surrounding masked area will usually develop more readily. Prolonged development with assistance of sodium bicarbonate or ammonia solution will be necessary.
	Masking inadequate	Same as for "Negative lacks density". Evidenced by easier development of areas where masking or negative overlapped.

PLATE MAKING DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Plate develops with difficulty in well defined areas (Cont.)	Out of contact areas	Especially noticeable in fine line or halftone work. Due to insufficient vacuum, thick masking or opaquing close to work areas, lumps of dirt on negative or plate, or kinks or dents in the plate. Avoid overlapping masking, and keep masking at least ½" away from work areas. Increase vacuum when fine detail is to be obtained from masked negatives, preferably using a single point source of light. Out of contact areas may sometimes be developed up by local treatment as described opposite "Plate fogged".
	Plate coating not uniform	Causes as under heading of same name. Localized development will be necessary in areas that develop with difficulty.
Develops too easily	Underexposure	Increase exposure on subsequent plates. An underexposed plate can sometimes be used by careful development with cotton, etching, and gumming, followed by "baking" plate in front of arc lamp for several minutes.
	Too thick a sensitized coating	While such a plate may be used for short runs, it will not provide full ink density on the press, and fine detail or halftones will gradually disintegrate ("walk off" the plate). Check density of solution. Add water or use faster coating speed for hot and dry atmospheric conditions.
Halftone "shadow" dots filled	Negative too thin	Dots on negative, particularly the pin point dots, lack sufficient density to hold back light. A longer "flash" exposure in making the negative is the usual remedy, though entire negative may require increased exposure or development. Follow procedure for "Negative lacks density" above.

PLATE MAKING DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Halftone shadow dots filled (Cont.)	Overexposed	Same treatment as for "Negative too thin". Plate must not be underexposed to compensate for thin negative, or a poor printing plate will result.
Halftone "highlights" dots lost	Negative fogged or plate underexposed	Highlight dots on negative (pin point openings) usually fogged, due to halation, overexposure, or other causes. A clearing bath will help negative, but the press-plate cannot be intensified satisfactorily to bring up partly exposed or missing dots. If time does not permit correcting the negative, a new plate should be made and overexposed to "burn" through the fogged areas in the negative.
Plate scummed	Negative scum	Due to pinholes in negative arising from dust on copy, copyboard glass, or negative, or due to minute gas bubbles in fresh developer. Cleanliness in negative making essential, but almost impossible to eliminate all dust and dirt. A slight over-exposure or over-development on line negatives will tend to fill in much of the dust spots, but of course cannot be applied to halftone negatives. Consequently opaquing or "spotting out" will always be required if negative scum is to be reduced. Rocking of the tray or agitation of the film holder in tank development will help eliminate small bubble formation on negatives. See albumen scum for treatment.
	Plate scum	Usually due to oxidized spots or pits in the plate, or to sand or dirt remaining on the plate following couteretching and washing. Very little can be done for oxide spots, and sand spots, as the plate itself is greased, though if not extensive some of the spots can be removed by rubbing them out with snakeslip, and then etching over these areas.

PLATE MAKING DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Plate scummed (Cont.)	Albumen scum	Resulting from incomplete development so that some of the albumen sensitizer remains in the grain and hardens there. Early discovery including a thorough application of a plate etch for a minute or longer, followed by washing with water and gumming thinly and uniformly will usually rectify this condition.
	Developing ink scum	Resulting from too thin an albumen coating or too greasy a developing ink that penetrates through the coating to grease up the plate itself. A strong etch may be effective as for albumen scum, but plate may have to be discarded. See under "Coating too thin".
	General	The application of a bichromated gum coating to the plate following development and etching, then exposing, washing, and gumming up the plate in normal manner is advisable whenever serious scum or similar difficulties are experienced with plates.
Developing ink streaks	Ink spread to non-printing areas	Insufficient drying of the developing ink coating, or a too greasy and slow drying developing ink, plus harsh rubbing in development without turning the cotton freely or using new cotton, will spread the ink on to the adjoining areas of the plate. If only poor ink is available, dusting the plate with french chalk (talcum powder), rubbed in over the deveolping ink and then drying for several minutes before development, will be found effective.

34.—PLATE PROCESSING SUMMARY

1. Prepare solutions, and select press-plate.
2. Place press-plate in sink and wash with brush and water.
3. Drain plate, flow counteretch solution, and scrub with brush for about a half minute, then wash well with water.
4. Place plate, (while still wet), in whirler. Start rotating at about 40 R.P.M. Pour clean water over plate, and immediately after most of water spins off, pour sensitizing solution on plate.
5. Turn on heat, close whirler lid, increase speed to 60 R.P.M. and allow plate to spin until dry.
6. Place sensitized plate on bed of vacuum frame and superimpose negative with masking in position.
7. Close vacuum frame, apply vacuum, tilt into vertical position.
8. Expose press plate through negative for required time.
9. Return vacuum frame to horizontal position, release vacuum, open frame, and remove press-plate to dry table.
10. Coat plate with a thin uniform application of developing ink, rub down smooth and fan dry.
11. Place plate in sink under running water, or in tray with water, and allow to soak for about a minute.
12. Develop plate with wad of cotton soaked in water, using light circular strokes (assist with sodium bicarbonate or ammonia solution only if necessary) until non-printing areas are entirely clean of ink and albumen.
13. Drain plate, apply plate etch with brush, and spread etch over plate continuously for about one minute, then wash off etch with water.
14. Drain plate, place on dry table, pour small quantity of gum on plate, and rub down smooth and thin with damp rag ball, avoiding gum streaks. Then fan dry.
15. If plate will not be used for several days or longer, or if required for a colored printing ink, wash off the developing ink image with turpentine, then pour a small pool of asphaltum on plate and rub down evenly with dry rag ball. Fan dry.
16. Plate is now ready for press.

Section VI

OFFSET PRESS

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Preparatory procedure and operation	37
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35. Principles of the Offset Press.— The offset press is an indirect rotary printing press, utilizing the lithographic principle of the mutual repulsion between water and grease to define the printing areas, and the intermediate rubber blanket to receive the inked impression from the press plate and to transfer it in turn to the paper. It consists basically of a structure supporting the three cylinders, and operating in conjunction with an automatic feeder and delivery. (See figures 4, 21, 22, and 23)

The three cylinders of the press are known as the plate, blanket, and impression cylinders, and their names are broadly descriptive of their function. They are geared together and operate in rolling contact, necessitating a high degree of accuracy in their construction, for otherwise excessive friction and misregister would occur.

The upper, or plate cylinder, is undercut below its pitch (or rolling) diameter and is provided with clamps so that the press-plate can be strapped around it in position, to become in effect, part of the cylinder itself. Water and ink are supplied to the press-plate through a series of distributing rollers issuing from the separate fountains. The ink fountain with its ink reservoir, feeds a thin film of ink, of controlled density, through the distributing and form rollers to the greasy areas of the press-plate. The water fountain has a similar, though less extensive, distributing system using rollers covered with a water absorbent wrapping.

The intermediate, or blanket cylinder, is also undercut to receive the rubber blanket, and is equipped with clamp bars and a reel, enabling the blanket to be stretched taut around its surface.

Both the plate and blanket cylinders are undercut below their rolling or pitch diameters by several thousandths of an

inch more than is actually required for the thicknesses of the press plate and blanket. This added tolerance is to allow for underpacking the press-plate and blanket with several sheets of paper as may be required to bring their surfaces up to true rolling contact (including the .003″ printing pressure). It also permits such subsequent changes in the underpacking as may be necessary to compensate for variation in size of the paper stock due to differences in the relative humidity occurring between the successive runs in a multi-color edition. A common difficulty of this nature results in "paper stretch" across the grain of the paper in the direction of rotation of the press due to the stock absorbing moisture in going through the press. In order to compensate for this stretch so as to bring the second color into register with the first, some of the underpacking is removed from beneath the press-plate and placed under the blanket, in this way changing the image size without altering the printing pressure. The maintenance of the .003″ printing pressure is essential to good printing, for too little pressure may result in grey or "blind" areas, while too much pressure (often mistakenly resorted to in an attempt to obtain better printing ink density), or excessive under-and over-packing, will cause serious surface friction between the press-plate and blanket, materially shortening the effective life of the plate.

The impression cylinder is usually manufactured to the full rolling diameter and ordinarily will not require a plate or blanket covering. The cylinder is however adjustably mounted to provide for different thicknesses of stock. It is also recessed to receive the paper grippers, whose function is to pick up the sheet as supplied to it by the feeder, then carry it through the press to receive the inked image from the rubber blanket, and finally to yield it to the delivery system that deposits and stacks the printed sheets in a pile.

The feeder has the function of separating the sheets of paper to be printed, and delivering them one at a time, to the press guides. It consists of an elevating platform that raises the paper gradually as the sheets are being passed through the press, together with a blower to separate the upper sheets, and a vacuum suction device to lift the top sheet off the pile, one at a time, and deposit it on the feeder board leading to the cylinders. As the sheet passes down the feeder board runway, it is accurately located by being brought into contact

with the front and side guides, where it stops momentarily to await the arrival of the gripper fingers on the impression cylinder that take hold of it and carry it through the press.

The chain delivery, where used, is also equipped with gripper fingers that seize the sheet just as it is being released by the grippers on the impression cylinder, then carries and deposits it on the delivery pile on an elevating platform, where the sheets are evenly stacked and gradually lowered as the printing progresses.

The lithographic inks used on the offset press differ from the usual printing inks in that they are stiff, greasy, and water-repellent, usually of high color density to compensate for the thin ink deposit required, and of a nature not readily affected by the constant exposure to water and fountain acid. A permanency of color, good drying qualities, resistance to rub or scratch, and a chemical inertness to injurious effects to the rollers, blanket or press plate, so that embossing on the blanket, deterioration of the rollers, or scum on the plates will not occur, are also important properties of a good ink. Litho inks are generally provided ready for use, requiring no thinning or "doping" with the exception of the addition of driers to aid in quickly "setting" the ink to prevent "offset" onto the back of the following printed sheet deposited upon it.

The paper supplied is made especially for the offset press, and while other varieties of paper can be printed, some are unsuitable because of a tendency to lint, pluck, or convey injurious chemicals from its coating or sizing that may affect and scum up the press-plate. Paper has similar properties to wood, in that it has a grain acquired in the process of its manufacture, and is subject to shrinkage and stretch depending upon its moisture content. This variation, due to its moisture content, is greatest across the grain, and as changing the packing under the plate and blanket on the press can only compensate for variations of size in the direction of travel of the paper, it is essential that the paper grain must always be parallel to the cylinder. As paper also bends and folds easier along the grain, especially in the heavier weights, keeping its grain parallel to the cylinder is further desirable. Paper may also have a "wrong" or wire side and a "right" or felt side resulting from its manufacture, and if printing is to be accomplished on one side only, the smooth or felt side should be used.

A controlled humidity of the press-room and the paper is the best means of minimizing paper stretch and associated difficulties. However, complete control equipment is seldom provided and a partial control is more frequently encountered whereby moisture or heat may be added to the room to obtain the required degree of relative humidity. With smaller presses, air conditioning is usually omitted as register and feeding difficulties are reduced, but even here a partial conditioning would be helpful.

The operation of the offset press requires both a mechanical and chemical control for satisfactory printing. The mechanical controls can all be definitely adjusted to function correctly with the aid of a few simple tools, and the chemical balance can also be correctly maintained with its own type of instruments. The proper balance and distribution of ink and water depending upon the plate requirements is essentially mechanical, but the nature of the ink and water is not. The ink used is a standarized product and no special testing equipment will ordinarily be needed to determine its suitability. But a satisfactory fountain solution must maintain a definite degree of acidity to minimize albumen swelling, plate scum, and breakdown of the ink. While trial and error means of determining the correct percentage of each ingredient have been used for many years, an exact control can be obtained by use of an instrument capable of measuring the acidity of the fountain. This instrument is known as the pH indicator, and a common type measures the acidity by the change of color that results when a sample of the fountain solution is mixed with a definite amount of the indicating dye.

36. General considerations.— The offset press is the proving grounds for all of the previous operations that were coordinated in the making of the press-plate from the negative. Yet successful printing is not only dependent on the supply of a satisfactory plate, but equally so on the proper adjustment and control of the offset press. The product turned out by the press must measure up to several definite requirements. They are:

Full density of color
Correct dimensions
Exactness of detail
Color register

Full color density means that the black ink must print black, and not grey; the red ink print red and not pink; and

so on with the other colors. It is also essential that the colors retain their intensity and do not vary or change during the press run. A good offset printing ink will not seriously fade or change color due to action of light or atmospheric conditions, nor will it react or emulsify readily when in contact with other inks or with the acid and water from a properly adjusted water fountain.

Correct dimensions cannot be entirely controlled when printing on paper, as paper is subject to shrinkage or stretch due to humidity variations. Proper adjustment of the press will enable the operator to obtain correct size in the initial printing, and assist in maintaining exact register over the entire sheet when adding the successive colors provided the humidity of the paper and pressroom are maintained constant during the time the several colors are printed on the map, and the paper stock is preconditioned to a humidity slightly in excess of that in the press-room. A relative humidity of 45% is regarded as the best value for press-room operation, but any other humidity that can be maintained throughout the press run is better than a varying humidity resulting from ineffective attempts to raise or lower it to this point.

Exactness of printing detail requires a proper control of the press, for too much water or fountain etch may sharpen up the work and eventually result in loss of fine detail as well as ink density, while insufficient water or too much ink will cause scum and fill in the small openings in the letters or in the shadow tints of the halftones. In addition, improper make-ready as regards packing under the plate or blanket can result in a slur of the fine detail or halftone dots, and eventually wear down the albumen image and the grain of the plate. Maintaining the correct acidity of the fountain solution is also important for obtaining satisfactory printing results.

Color register will not be found difficult to maintain, if the pressroom and paper humidity remains fairly constant during the run. The mechanical prerequisites for maintaining register are proper adjustment of the feeder, wheels and brushes so that the paper will feed correctly into the press, each time the additional color is added.

The initial adjustments of the press are provided for at the time of its installation and should never be disturbed until poor printing resulting from continued usage, or special requirements necessitate it. Certain simple mechanical ad-

justments are necessary whenever the press is put into operation, and others will subsequently be required to compensate for wear or special conditions, but it must always be emphasized that the offset press is a very accurate and delicately balanced unit of equipment, easily thrown out of adjustment by improper handling, and that under no circumstances should any major correction involving the timing, the grippers, or the alignment of the cylinders be made without positive evidence that they are the cause of the difficulty, and then only by someone thoroughly familiar with their proper setting.

37. Preparatory procedure and operation.— The procedure in undertaking operation of the press will consist of:

A. *Conditioning Paper.* Where paper conditioning facilities or space are available, hang or stack the paper, winding it at frequent intervals to get the air between the sheets so that it can acquire a humidity equal to or preferably slightly in excess of that in the pressroom. Conditioning in a room or compartment with a relative humidity 5% above that of the pressroom is best in order to compensate for the moisture subsequently acquired on the press. This minimizes the tendency of the paper to stretch, wave, or curl as well as assists in maintaining uniform size and register during the subsequent color printings. Conditioning will not always be possible and when serious paper difficulties are experienced due to humidity variations in the field, an effective treatment of the stock can sometimes be secured by running it through the press blank, with a blank plate and dampeners on, if moisture is to be added to the paper.

B. *Lubrication.* All moving parts of the press, with the exception of the press bearers, must be lubricated regularly to provide for continued satisfactory operation. Instructions for proper lubrication accompany each press, but where they are not available, the following will govern:

Oil daily:

All oil holes marked "oil" or indicated with a red spot.

Tumbler shaft and gripper shaft at each end of impression cylinder. (Use long spout oil can and wipe off excessive oil.)

All ink and dampener roller bearings.

All cam rollers.

Oil weekly:

Delivery chains using penetrating oil (consisting of S.A.E. 20 oil reduced half and half with kerosene.)

Grease weekly:

All gears with gear compound, after first cleaning out any accumulated dirt between gear teeth with a small bristle brush.

All fittings on feeder, fountain, and press bearings.

Oil or Grease:

Electric motors at intervals recommended on instruction sheets.

C. *Mounting Blanket*

a. Attach the metal bars to each end of the blanket, centering them accurately to a centerline drawn at right angles to one end of the blanket, positioning the bars exactly parallel with each other before scribing and punching the holes to receive the clamping screws. Then punch holes, reassemble accurately and tighten all screws. (It is important that the bars be accurately attached to the blanket so that the blanket will be uniformly stretched around the cylinder. Where possible, a metal templet should be prepared having holes drilled in the proper location. By superimposing this templet over the blanket, the exact location for the holes can be transferred to it, so that they can be correctly punched and attached to the bars. Because of the time delay involved in mounting a new blanket it will be advantageous to have a second blanket available with duplicate clamping bars attached.)

b. Wipe the face and back of the blanket with a dry rag and also clean the surface of the blanket cylinder. (In applying a new blanket, thoroughly wash its surface with a rag pad and clean water, assisting with pumice powder and scrubbing evenly if difficulty is experienced in cleaning its surface. Then powder the surface with a blanket powder consisting of a half and half mixture of flowers of sulphur and french chalk tied in a muslin bag, and finally wipe clean with a dry rag.)

c. Attach the front end of the blanket with its bar, into position on the blanket cylinder.

d. Measure the average blanket thickness at several points with a micrometer, (avoiding compressing the rubber.) Obtain several sheets of paper of the same width and sufficiently long to completely underlay the blanket so that their combined thickness added to that of the blanket will bring the surface of the blanket up to the required height stated in the press manual (the total to provide .003″ squeeze between

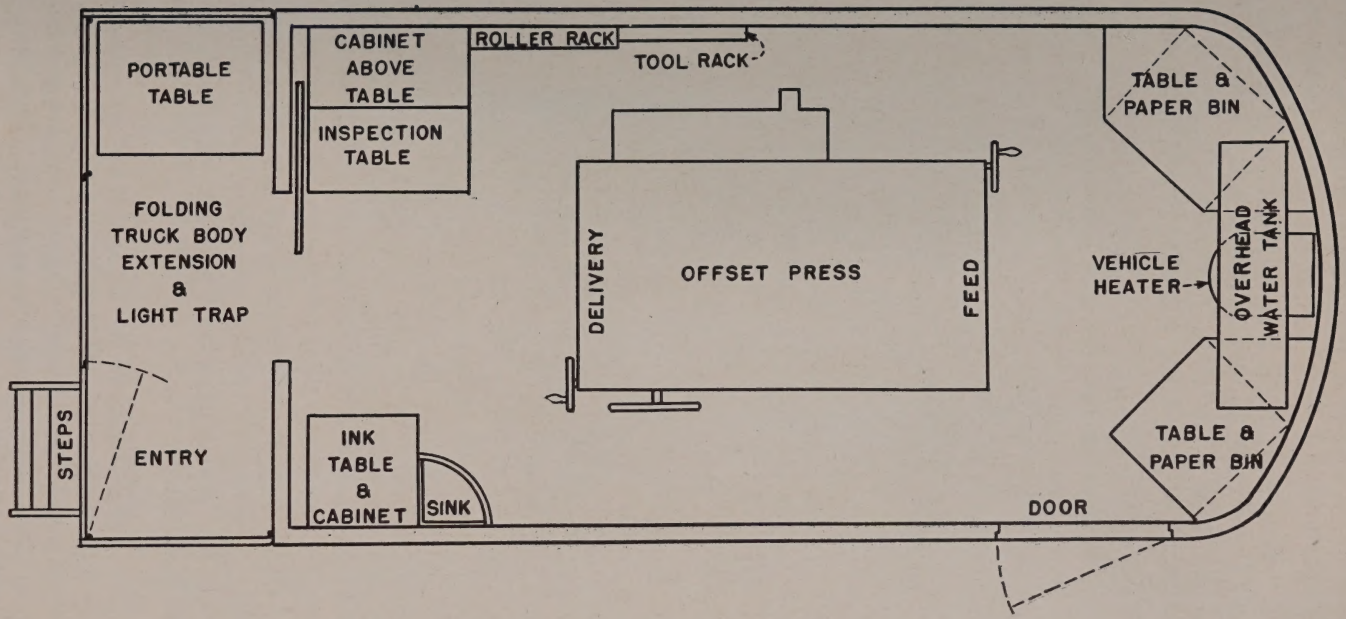

Figure 20. Mobile Press Unit.

the plate and blanket), and insert the paper under the front end of blanket.

e. Then turn press over by hand, so as to draw the blanket and paper packing around the cylinder, observing care that the paper does not wrinkle. Insert the back end of the blanket with its attached bar into the reel rod, and bolt in position.

f. Stretch the blanket taut over cylinder, using only the wrench provided, and holding the cylinder against movement by inserting the cylinder stop pin located on the operator's

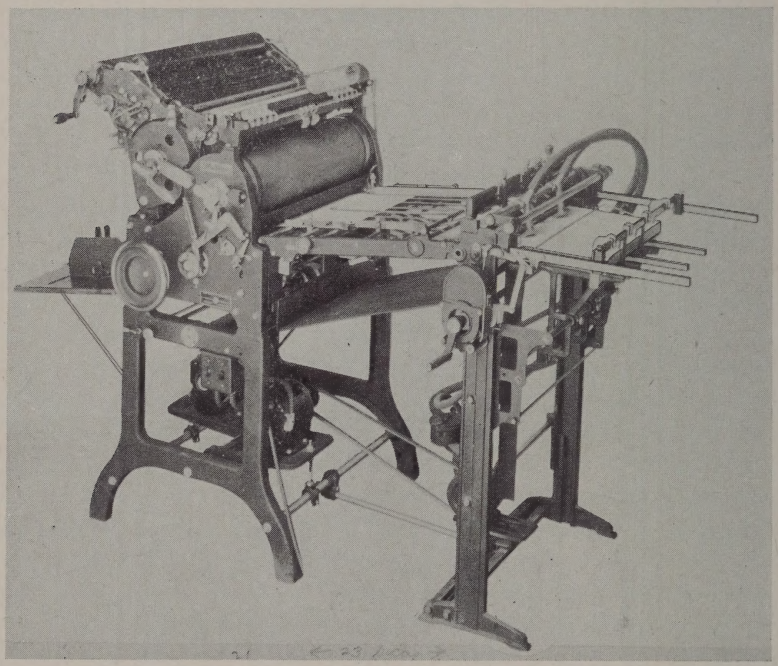

Figure 21. 19″ x 20″ Offset Press (Multilith).

side of blanket cylinder. Then start press rotating with plate pressure against the blanket for about half a minute or until the first few sheets have been printed. Again tighten blanket to remove stretch.

D. *Mounting press-plate:*

a. Immediately upon receiving the press-plate, check for errors in position as well as in detail, comparing it with "proof" copy or other reference sheets available. If satisfactory, proceed as follows:

b. Extend press reference marks on the press plate to the sides and gripper center of the plate if not already printed or drawn in.

c. Wipe off the back of the press-plate and the face of plate cylinder with a sponge and water followed with gasoline on a rag, and dry with a clean rag.

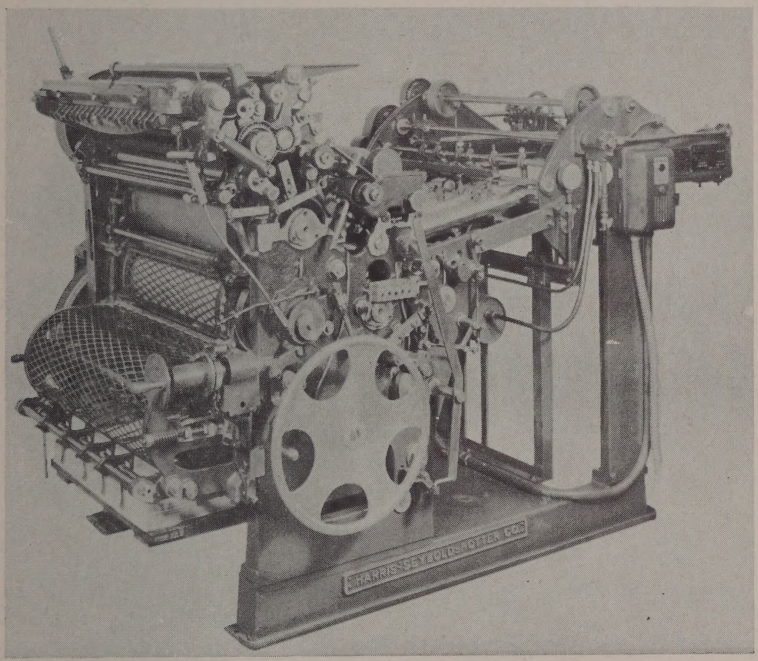

Figure 22. 20″ x 22½″ Offset Press (Harris).

d. Loosen all plate clamps on the plate cylinder.

e. Loosen all clamp set screws.

f. Lock ink rollers up in off-contact with plate position.

g. Put press on impression, by pushing impression throw-on lever down after first placing a strip of paper under the sheet detector, or (on the Harris press), insert bar between pin on impression arm and throw on impression manually. Then turn the press over one revolution with the hand wheel.

h. Insert the front edge of the press-plate centrally into the plate gripper bar, aligning the reference marks on the plate edges with corresponding center and side marks previously engraved on the gripper bar and press cylinder, and tighten clamping bolts from the center outward. Then raise

clamp bar and lock in position with the bolts in the clamp slots.

i. Measure average thickness of the press plate with the micrometer.

j. Obtain one or more sheets of paper for underlaying the plate so that the total thickness of the plate and underlay will be .001″ above bearer height (plate cylinder is usually undercut by .015″). Then carefully insert the paper under-

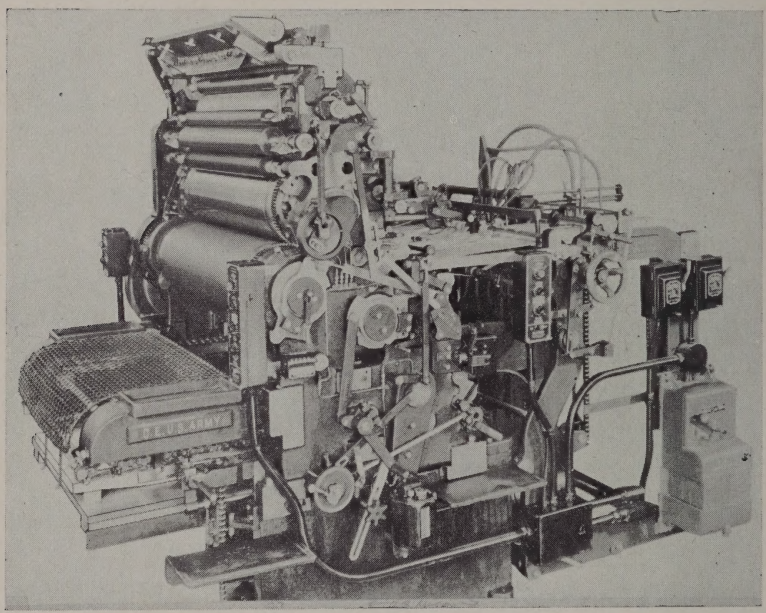

Figure 23. 22″ x 29″ Offset Press (Webendorfer).

neath gripper edge of press-plate and turn press over by hand making certain that the paper does not wrinkle under the plate as they are being drawn around the cylinder.

k. Insert the back end of the plate in the rear clamps (bending the plate slightly if necessary) and tighten the clamps.

l. Remove paper strip from sheet detector. Trip press and revolve one turn "off" impression.

m. Again check clamps for tightness and make certain the plate is drawn taut around the cylinder. (Usually tested by tapping the portion of the plate bridging the clamps and cylinder for a "solid ring").

n. Finally lock the bolts in the clamp slots.

E. *Fountain Solution:* Prepare fountain solution by using one ounce of etch to each gallon of water and adding phosphoric acid until an acidity between 3.8 to 4.5 is obtained as shown on the pH indicator. (Where pH testing equipment is not available, the phosphoric acid content can be doubled or the alternate formula listed in the tables can be used).

Pour the prepared solution into the water fountain so that the bottom portion of the brass or covered fountain roller is immersed to a depth of ¼ to ½ inch. (Fig. 24)

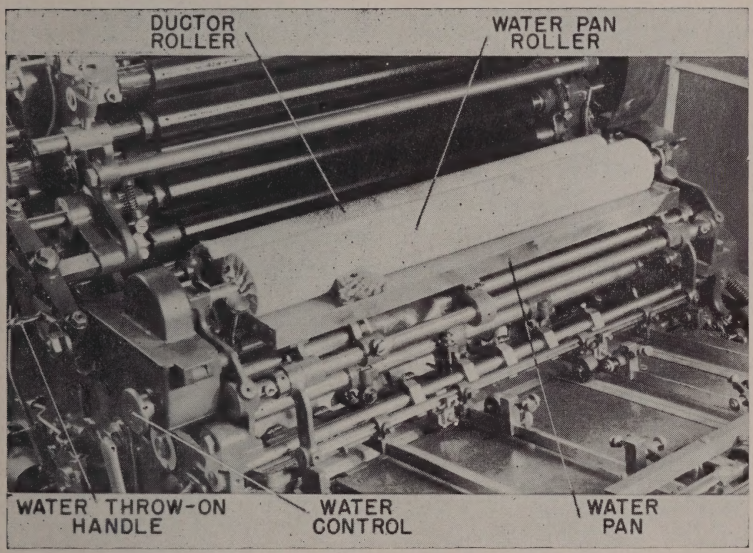

Figure 24. Water Fountain.

F. *Dampening Water Rollers:* Wet all dampening rollers evenly with a sponge. The dampening rollers must be completely damp so that they do not accept ink from the plate, yet not so wet that the water collects on its surface.

G. *Ink:* Prepare the ink for the press by removing a definite quantity from the can with the ink knife and placing it on a clean slab. Then add a half and half mixture of paste and cobalt drier in the proportion of ½ oz. of the mixture to each pound of ink used, and work it thoroughly into the ink by turning it over and "kneading it" with the ink knife. (Note:— The ratio between driers and the percentage of drier used with the ink will require adjustment depending on the color and make of ink used as well as the consideration of whether subsequent colors are to be overprinted. The paste drier is a slow drier and so better adapted to multi-color work,

while the cobalt drier is a fast and hard surface drier better suited for higher speeds and coated stocks. Too much drier may make the ink "chalky" or cause "stripping" of the rollers, and emulsify the ink, while too little drier will prolong the drying period, and may result in "offset" of the printing ink onto the back of the subsequent sheet deposited on it in the press delivery pile.)

Avoid "doping" the ink with varnish, excessive drier or other ingredients, except when special conditions such as plucking of a coated or a soft stock requires the addition of some #00 varnish, or a high press room humidity or offsetting of the ink on the back of the next sheet necessitates additional drier, in each case keeping a record of the amount added to the particular ink so that the same ink can subsequently be properly mixed in advance when encountering similar conditions.

Using the ink out of the can as furnished plus the required amount of drier, will ordinarily give the best results on the press.

H. Make a preliminary adjustment of the ink fountain thumb screws, first turning them into a light contact (do not force the screws as the blade can be bent out of shape) then opening each about ½ turn for a corresponding printing ink coverage of 25% of the total plate surface. (For map work—a uniform opening of about ½ turn, or .015″ gap as tested

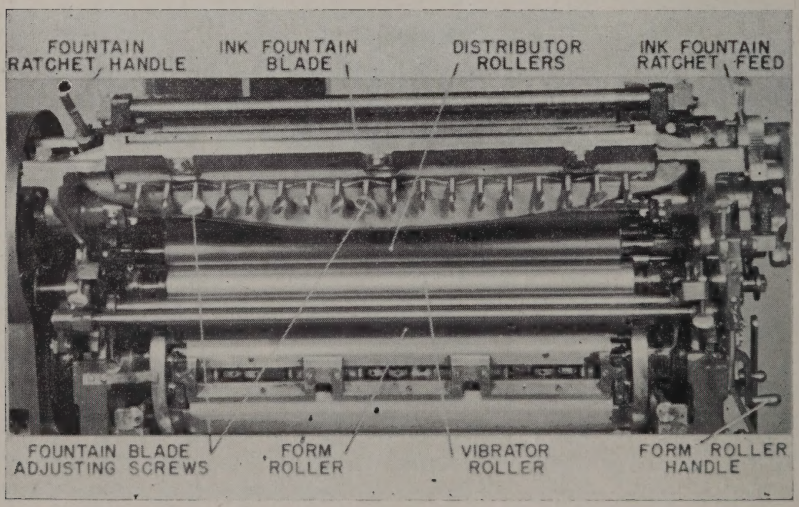

Figure 25. Ink Fountain.

with a feeler gauge can be used in the preliminary setting.) Set ink fountain ratchet pawl in half way feed position. (Fig. 25)

I. Transfer the ink to the ink fountain, spreading it along the fountain roller in a uniform layer.

J. Bring the ductor roller into contact with the fountain roller, then turn fountain roller hand crank and examine ink distribution by thickness of ink layer on roller. Open or close thumbscrews if necessary so that the ink layer will correspond to the approximate ink requirements along the plate.

K. Check ink rollers for proper contact with each other and with the plate using thin slips of paper or a .003″ feeler gauge, whenever doubtful of their correct setting. Finally test by dropping the inked form rollers against the gummed up plate, then raise them and note the ink marks for uniform 3/16 or ¼″ wide bands on the plate. If adjustments are required they should be made in acordance with the instructions in the press manual. (The end of each ink roller shaft should be numbered or marked so as to facilitate their replacement on the press.)

L. Jog the paper to "wind" it properly so as to separate the sheets and get air between them, and then load it centrally on the feeder elevator, stacking them carefully against the side and rear guides. (Side guide adjustable for centering pile). Add about 50 "waste" sheets interleaved with about 10 clean sheets to the top of the pile to be used in adjusting the ink and guides in starting the press.

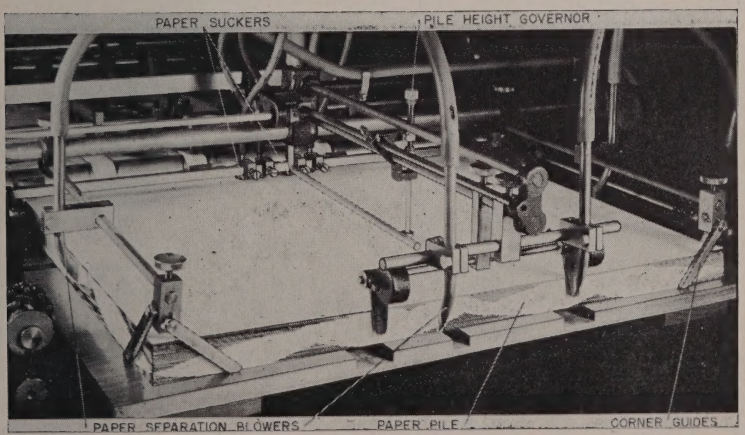

Figure 26. Press Paper Feed.

M. Raise feed elevator by turning hand crank until top of paper pile is about ¼″ below the pile height governor. Then set the corner guides against the paper pile, and position the paper separation blowers along the back (and sides where provided) about ½″ away from the paper pile. Adjust suckers, on presses so equipped, so that they are positioned between the feed rollers. (If paper pile does not lie flat the suckers may require repositioning to feed properly.) Then turn the press over by hand until the suckers are at their lowest position, and raise the paper pile until the top sheet is ¼″ below the suckers. (Fig. 26)

N. *Adjusting guides.*

Adjust the two-sheet choke by means of thumb screw so that one sheet of paper can be passed through freely, but that the thickness of two sheets will catch and prevent passage of the paper.

Set the sheet stripper finger by turning the adjusting screw until the spring fingers press lightly against the top of the pile, completing the adjustment after the feeder is in operation by increasing or decreasing the pressure against the fingers to the maximum amount that will not prevent the sheet from being lifted by the suckers.

Turn on the feeder pump switch, or valve, adjusting the air pressure on the blowers so that they separate the several

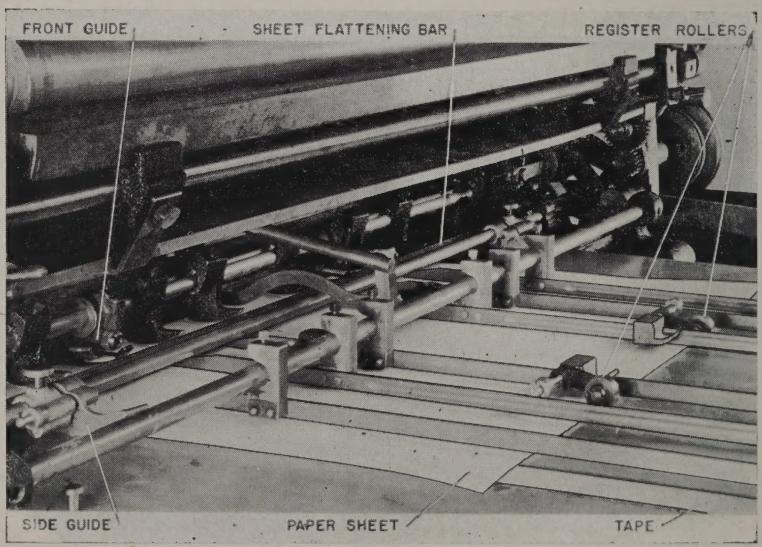

Figure 27. Press Feed Board and Paper Guides.

top sheets, and increase or decrease the vacuum until the suckers will pick up the top sheet only when in their lowest position (using less vacuum for thin (manifold) stock to avoid the tendency to pick up more than one sheet). The feeder governor is also adjustable and must be set to keep the paper pile elevated to the correct height during the run. Set the front guides in approximately central position to allow for adjustment in subsequently obtaining correct "lay" of the printing subject on the paper. Then jog press so that it rotates slowly, throw on feeder valve, allow feeder to pick up one sheet and deliver it onto the feeder board (belt runway) until it reaches the front guides. Also bring feed pressure rollers into contact with the belts so that the sheet of paper will be driven straight through to the front guides. (Fig. 27)

Next set the tension or register rollers so that they just clear the back edge of the sheet yet hold it in contact with the front guides and allow the free movement required for its positioning by the side guide.

Then with the sheet of paper still in the position where it just touches the front guides, turn the flattening or pressure bar adjusting screw so that the bar holds the sheet flat to stiffen the paper for side guide thrust, but does not press against the paper. The side guide can be adjusted to a preliminary position so that it will push the sheet in approximately 3/16″ in centering it against the front guides.

O. *Delivery.* Feed a sheet slowly through the press so that it is released on the delivery elevator plaform, and continue to turn the press over slowly until the side joggers are at their closest position to the paper. Then move the side and back joggers inward until they just contact the edge of the sheet. (Fig. 28)

P. Throw the ink fountain lever on so that the ink distributes itself over the drum, riders, and rollers, making such adjustments with the fountain screws as appear advisable to obtain uniform coverage over the rollers in proportion to the plate requirements.

Q. Sponge off the plate with water to remove the gum coating on its surface and to dampen the plate thoroughly. Then start press into rotation. Move dampeners forward to contact the plate by pressing on "water" lever, (observing that the gear on the flywheel side of the press meshes first), then lock in position, next drop the form rollers on to the plate and allow the press to turn over four or five times. Then

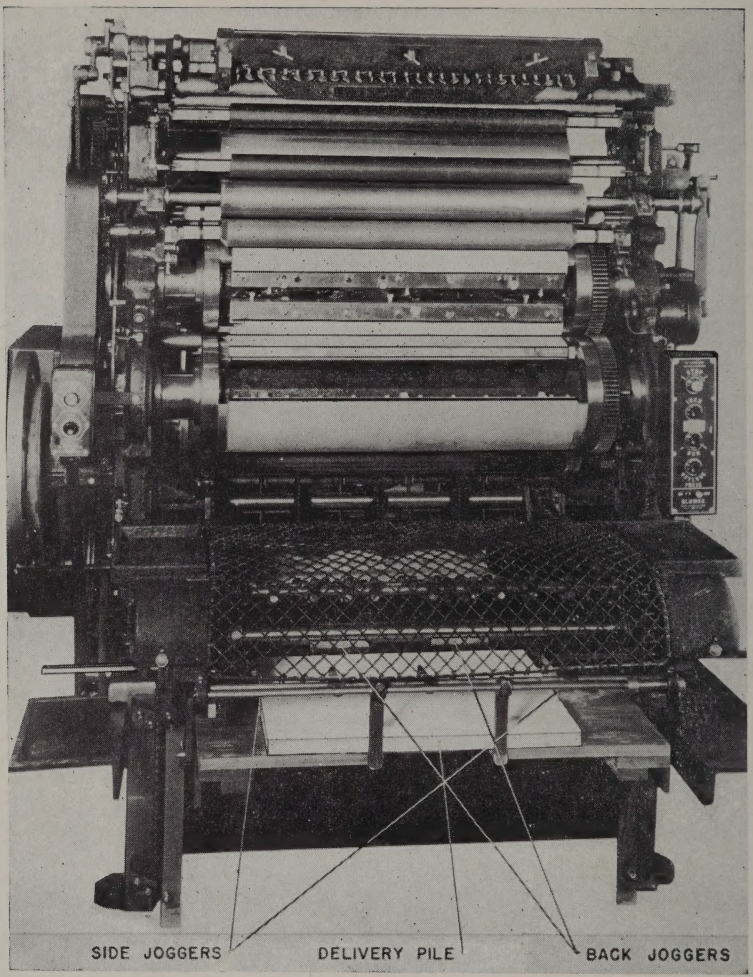

Figure 28. Press Delivery.

raise the form rollers, release dampeners, stop the press, and examine the plate to make certain that the entire printing design is taking ink, indicating a properly adjusted press and a satisfactory plate. Start press into operation again, turn on feeder pump, lift and deliver a sheet down the tapes on the feeder board and as it reaches the front guides, push down the impression lever, allowing about a half dozen waste and a clean sheet to pass through the press before turning the feed pump switch off. Allow press to continue rotating, and examine the clean sheet for "lay" and printing defects. (The press will automatically throw off impression when the paper stops feeding.)

R. If the printing areas are properly located on the sheet and no defects are evident, press production can begin. If corrections are necessary, proceed as follows, (observing that if the press is to be stopped, the dampeners and form rollers should first be released. The plate must also be gummed up with a thin uniform gum arabic coating whenever such adjustments will require more than a momentary stoppage of the press, for otherwise slow drying of the water may oxidize and scum the plate).

38. Press Adjustments.— *a. Inked Impression Twisted on Sheet*

Some correction for this condition can be obtained by adjusting the front guides, moving them in or out as required, to correct the twist and obtain the required gripper distance, but only by a limited amount as excessive adjustment may interfere with proper feeding of the stock. Additional twist due to the printing image being incorrectly exposed on the plate or to the improper mounting of the plate, can to a certain degree, be compensated for by twisting the plate on the cylinder, loosening the lock and tension screws on one end of the plate gripper bars and tightening the opposite ones by the required amount, stretching the plate taut after the adjustment is made. Repeat these operations after running through several waste and a clean sheet if insufficient or excessive correction has been made that cannot be compensated for by adjustment of the front guides. (Avoid forcing the plate in twisting on the cylinder or the metal itself may be stretched out of shape, resulting in local misregister).

b. Inked Impression off Center Sideways on Sheet:

When not due to a serious misplacement of the image in making the plate, this condition can easily be rectified by adjusting the side guides by the exact distance the inked impression is off center on the paper.

c. Inked Impression Incorrectly Positioned with Respect to Gripper (front) Edge of Sheet:

A minor correction can be made on the front guides, adjusting them uniformly so as not to twist the sheet. A major correction will require shifting of the plate cylinder, and is accomplished as follows:—Mark the amount of the correction required on a strip of paper. Then pencil a short mark on the bearers opposite the edge of a gear tooth, or to some other reference point, and add a second mark showing the proper

direction and distance for the correction indicated on the paper strip. Release the bolts clamping the gear to the plate cylinder and turn the press slightly by hand until the tooth edge or other reference point comes opposite the new mark. Then tighten all the gear clamping bolts.

d. Removing Scum or Defects:

Local scum that cannot be removed by sponging with water should be carefully etched away by applying concentrated fountain etch with a small sponge or flannel pad, rubbing lightly until the scum is removed, then sponging the etch off with clean water. Unwanted marks are removed by rubbing out with a snake slip or a red rubber eraser and applying concentrated plate etch locally to desensitize the exposed metal, then sponging with clean water, at all times keeping the rest of the plate damp by frequent sponging so that no part of it tends to dry.

To fill in broken rules or lettering, sponging the plate with water, drying locally, and adding corrections with a hard lead pencil is sometimes effective. For fine detail, gum the plate evenly, fan dry, and then engrave through the gum with a needle or scraper. Avoid contacting the plate with the hands, resting them on an arm rest or a clean sheet of paper. After the lines have been engraved through the gum coating, rub in a thin film of offset, roll-up, or press ink using a small piece of rag (or the finger) for its application.

e. When all the necessary adjustments have been made to square up and locate the printing image on the paper, and to correct any defects or a scum condition, gum up the plate (if not already gummed) and fan dry. Then wash the image off the blanket with a rag dampened in benzine or a white (lead free) gasoline, and if the blanket appears tacky after drying, dust with a blanket powder consisting of a half and half mixture of flowers of sulphur and french chalk, contained in a small muslin bag. Finally wipe the excess powder off with a clean rag retained for this purpose. Then place a dozen or more waste sheets on top of the paper pile, if none remain from the original supply, and start the press into actual operation by washing the gum off the plate, bringing the dampeners and then the ink rollers into contact and starting the paper through the press, as previously detailed in steps 37 Q & R.

f. Adjustments required during press operation.

The continued operation of the press may necessitate some attention to the feeder but will consist essentially of maintaining a proper balance between the ink and water distribution systems so that a full density of ink, without scum, is transmitted to the paper. This will require setting of the ink fountain thumb screws so that the proper proportion of ink is transmitted to the plate in meeting the local requirements, beginning with approximately a half turn for each quarter section of the plate that is covered with a heavy ink form, as described in step 37H, and with the ink fountain roller pawl set to feed about half the range of notches for each revolution, then increasing or decreasing where necessary to obtain full density of ink. Full printing density cannot be obtained when too much water is carried on the plate, or too alkaline or acid a condition of the fountain is permitted that varies considerably from a pH of 3.8 to 4.6. The water supplied to the plate by the fountain should always be kept to a minimum to obtain best printing quality, but carefully watched so that it does not fall off to the point where the plate will "catch up" by accepting ink in the non-printing areas. Should the ink "catch up", immediate local dampening with a sponge and a slight increase of water feed from the fountain will ordinarily correct this condition. If the "catching up" is severe and not easily removed with the sponge and water, it will be necessary to stop the press and carefully etch out the affected area with a sponge and concentrated fountain etch until clean, and then wash off the etch with a sponge dampened in clean water. The nature of the paper stock being printed may require some adjustment of the ink. If coated stock is used and the tack of the ink causes plucking in the solid areas, it may be necessary to add No. 00 varnish to the ink, a little at a time and mixing thoroughly until the plucking ceases, keeping a record of the amount added to the quantity of ink in the fountain, so that the ink may be properly prepared in advance when the same type of paper is again used. A coated stock may also necessitate the addition of as much as another half ounce of drier to the pound of ink, especially when operating under damp humidity conditions.

A tendency to tint is sometimes counteracted by increasing the etch in the fountain, though this should only be done if a pH test for acidity shows the fountain to require the addition of acid. Otherwise the scum should be removed by local application of the concentrated plate etch with a sponge

or with a square of flannel, and then washed clean, as operating the press with too acid a fountain will affect the inks and undermine the highlight dots. Similarly, insufficient acid in the fountain may result in a softening of the albumen image, with a corresponding loss of ink attraction and density, that if continued too long will also cause the image to dissolve away or "walk" off the plate. It is consequently advisable to check the acidity of the fountain solution daily, or more frequently when scum or other difficulties warrant it. Although no provisions are made on the water fountain mechanism to control the local transfer of moisture to the plate, corrections can sometimes be obtained by allowing the water stops furnished to drag or squeegee off part of the water from the fountain roller and so reduce the amount of moisture applied to the corresponding area on the plate.

Some paper stocks have a tendency to "lint" freely, and this condition may require frequent press stoppages to wash out the plate, blanket and form rollers, as well as cleaning the suction lines in the feeder. If at all possible, this type of paper should be avoided.

g. After the run has been completed, or whenever the press is stopped to clean the blanket, to add or remove the paper stock, or for any other reason, the form and dampener rollers must be released and the plate gummed up with a thin uniform coating of gum to prevent oxidation of the plate. If the run has been completed, the plate is removed from the press after gumming and drying, placed on a flat table, sponged out with water and gummed again, using a damp rag and applying a thin uniform coating of gum as detailed under Plate-making Procedure, step 27p and fanned dry. The inked image is then washed out with a rag and turpentine. If the plate is no longer required, it will be returned to the graining department in this condition, but if a re-run is expected, a final coating with asphaltum, spread uniformly and rubbed down smooth and thin, will follow, and the plate can then be stored indefinitely in a dry place.

h. Finally, the press must be cleaned up at the conclusion of the days run to remove all ink from the fountain, rollers, dampeners, and blanket. If a sizable quantity of ink remains in the fountain, it can be placed in a can and covered with a sheet of paper oiled with machine oil or #00 Varnish pressed in contact with its surface to reduce the tendency of the ink to dry. The ink fountain and rollers are then thorough-

ly washed up with gasoline or benzine with the assistance of the washup attachment and a rag, until all the ink has been removed, and the remaining solvent wiped dry with a clean rag. Thorough washing is essential as any ink remaining in the pores or on the ends of the rollers, or in the fountain will dry hard and result in future printing difficulties. The blanket is washed alternately with gasoline and water to remove both ink and gum deposits. The dampening rollers and fountain pan are similarly cleaned with alternate spongings of water and gasoline, assisted with a scrubbing brush or a flat or curved blade to remove the ink deposits on the surface of the molleton. A general clean up of the press should follow, removing ink and gum deposits from the plate, blanket, and impression cylinders, especially along the gap and bearers of the plate and blanket cylinder; also cleaning and oiling the wheels, guides, suction line and all operating parts in accordance with instructions, to keep the press in readiness for immediate operation. If the press is not to be used for several weeks or longer, it must be well lubricated and greased. The tension on the blanket must be released, or the blanket removed and hung to allow the ink and other solvents to evaporate out of its pores. The ink rollers can remain in location with pressure released, or they may be removed and supported in brackets to prevent "flats" developing from resting in contact with each other for a long period of time. The press cylinders may also be greased or waxed to prevent their rusting.

39. Press formulae.—

Press Fountain etch.

Stock a.	Ammonium dichromate	½ oz.
	Water	3 oz.
b.	Gum Arabic Solution (14° Baumé)	12 oz.
c.	Phosphoric acid	¼ oz.
Water		1 oz.

Dissolve separately, mix. For use pour one ounce of stock into 1 gallon of water and add phosphoric acid to obtain pH of 3.8 to 4.6 (from 0 to 1 oz Phosphoric acid)

Alternate Press Fountain Etch.

Stock a.	Ammonium dichromate	1 oz.
	Phosphoric acid (85%)	1 oz.
	Gum arabic solution (14° Baumé)	7 oz.
	Water	24 oz.
Stock b.	Magnesium Nitrate	16 oz.
	Gum arabic solution (14° Baumé)	2 oz.
	Water to	64 oz.

For use:— 1 oz. a and 2 oz. b to 3 gallons water. Increase or decrease proportion of stock a to obtain acidity of 3.8 to 4.6 (pH)

40.—PRESS DIFFICULTIES

GENERAL: DO NOT DISTURB ADJUSTMENTS ON PRESS UNLESS A DEFINITE DEFECTIVE MECHANICAL CONDITION IS FOUND, AS MOST PRESS DIFFICULTIES ARE DUE TO IMPROPER OPERATION; OR UNDERPACKING BENEATH PLATE OR BLANKET; INCORRECT DISTRIBUTION OR BALANCE BETWEEN INK AND WATER; A POOR PLATE; EXCESSIVE PRESSURE ON FORM OR DAMPENING ROLLERS; OR THE HUMIDITY. (IN MAKING ADJUSTMENTS CONSULT MANUAL FURNISHED WITH PRESS)

DIFFICULTY	NATURE	REMEDY
Plate will not take ink	Form rollers do not contact plate	Drop form rollers to contact plate. If setting is required, adjust form roller bearings until all rollers contact plate uniformly, testing first with a .003″ feeler or slips of thin paper, and finally by uniform ¼″ ink streaks when inked form rollers are dropped on a dry gummed plate. (Plate must first be properly underpacked)
	Plate entirely "blind"	Rare condition but may be caused by combination of under-exposure, and excessive etching and gumming in making plate. Replace plate.
Plate not inked uniformly	Ink fountain incorrectly adjusted	Start with ink fountain blade set to uniform gap of .015″ (or one-half turn of thumb screw), then adjust screws as required by work on plate after printing has started.
	Rollers improperly set	All rollers must contact lightly and uniformly. Use .003″ feeler or thin paper slips for adjusting rollers against each other and against plate (see above).
	Rollers glazed	Usually due to ink and dryer remaining in pores of rollers. Thoroughly wash with gasoline or benzine when shutting down press. Glazing can be removed by rubbing with fine pumice and gasoline. If extensive, have roller reground, or recovered.

PRESS DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Plate not inked uniformly (Cont.)	Metal riders or drum "stripping"	If due to glazed rollers, correct rollers as above. Otherwise try 2% nitric, acetic, or hydrochloric acid wash together with pumice powder on riders or drum. Wipe with gasoline before, and water after applying the acid.
	Dampeners improperly set	See "Dampeners".
Will not print on blanket	Bearers not in contact	If pressure is "on" and bearers still do not touch, consult press manual for proper setting of blanket cylinder pressure adjustment.
	Blanket or plate insufficiently packed	Add proper underlay sheets under plate or blanket, as required, to bring plate up to .001" above bearer height, and blanket to .003" printing pressure with plate.
Uneven print on blanket	Insufficient pressure	Check underlay under plate and blanket as above. Add packing where required.
	Low areas	May be due to uneven or worn blanket or to injury or warping of cylinder. Under-pack low areas of blanket with pieces of tissue paper marked and torn to conform to shape of low areas, building up with additional reduced sizes of tissue as indicated necessary by subsequent impressions. (Tissue to be attached with rubber cement to underside of blanket)
	Dents in blanket	Dents, if not severe, will usually disappear if left alone for a while. If deep, turpentine or commercial preparations such as "Quik" may be used, or it may be possible to shift the plate or reverse the blanket so that the dent will not show in the printing.
	Blanket glazed	Wash thoroughly with water and gasoline to remove gum and ink deposits. If still glazed, remove from press, place on flat table, and scrub surface well with gasoline and pumice powder.

PRESS DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Uneven print on blanket (Cont.)	Water and Ink distribution unbalanced	Check and correct ink and water distribution (see notes on inking)
	Defective plate	Inspecton of plate in doubtful areas with magnifying glass will tell if plate is at fault. May be due to under-exposure, blind areas, or etched too deeply, if a deep-etch plate. Try corrective measures opposite "Ink impression grey", or replace plate.
	Cylinders not parallel	Consult press manual for correction.
	Gum streaks	Gum not applied smoothly or rubbed down thinly and evenly in either plate making or on the press. More pronounced if gum has soured. Results in image areas being desensitized to grease. Washing out with a plate wash as described under "Ink Impression grey", or rubbing up wet with alternate strokes of a wet sponge and a rag rubbed in press ink (or preferably rub-up or transfer ink), will sometimes revive image.
Will not print on paper	Feeder, guides, or trip improperly set	See "Paper"
	Impression cylinder too low	If good print on blanket, increase pressure on impression cylinder until an even print is obtained. When cylinders are out of parallel or not equipped for parallel movement, adjust for thickness of stock, using strips of the paper to be run as "feelers" on both sides of the cylinder, and then adding .003" printing pressure. (see press manual for location of adjustments).
	Blanket insufficiently packed	Check blanket and underpacking to bring blanket surface to .003" printing pressure with plate. When printing on manifold or similar thin stock, it may be necessary to increase blanket under-packing to bring surface to .003" above bearers, removing corresponding packing from beneath the press-plate to maintain .003" pressure.

PRESS DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Will not print on paper (Cont.)	Bearings worn.	Major correction. Consult press manual.
Non-Uniform print on paper	Impression poor on plate or blanket	See corrections for plate or blanket
	Impression cylinder out of parallel	Adjust as for "Impression cylinder too low" (see above)
Ink impression too heavy	Too much ink	Reduce by adjusting ink feed or ink fountain thumb screws.
	Ink too soft	Avoid adding varnish to ink unless necessitated by plucking of coated or soft stock. If ink is too soft, use small quantity of #8 varnish and work in thoroughly to stiffen ink.
	Insufficient water	Usually associated with local "catch up" of ink. Increase water to minimum required to print properly.
	Image slurred	Resulting from excessive underpacking or overpacking plate or blanket, or to glazed form rollers slipping. Correct cause.
	Image doubled	Due to loose blanket or play between plate and blanket cylinders. Tighten blanket. If gear segment requires adjusting to remove play, consult press manual.
Ink impression "grey"	Too much water	Reduce to minimum required that will print without ink "catching up."
	Insufficient ink	Increase ink supply at fountain
	Fountain solution too acid or too alkaline	Keep acidity between a pH of 3.8 to 4.6 by changing fountain solution or adding phosphoric acid, as required.
	Poor plate	Gum up evenly and thinly, fan dry, wash out with turpentine and follow with prepared washout solution such

PRESS DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Ink impression "grey" (Cont.)		as "Holtite" or "Nowok". Dry, then wash with sponge and water and ink up again. If this does not help, obtain new plate.
	Blanket glazed	See "Uneven print on blanket" above
	Insufficient underlay or printing pressure	Check plate and blanket for proper packing to bring plate .001" above bearers and blanket to .003" printing pressure. See also "Will not print on paper".
	Water in ink	Ink emulsified. Replace ink.
Plate scums, tints or catches up.	General	Attempt immediate removal by sponging with water, or with plate etch (concentrated fountain solution) if severe. Then correct cause.
	Defective plate	Will become evident at beginning of run as general or localized tinting. Due to old albumen, incomplete development, too thin a coating, poor negative, greasy developing ink, etc. Attempt to clean up plate with strong plate etch or concentrated fountain solution, alternately sponging with etch and water. If this does not remove scum obtain new plate. (Local tint scum may be removed with snake-slip, followed with plate etch, then washed with water).
	Insufficient water	Increase to minimum amount required to prevent plate "catching up"
	Insufficient acid in fountain	Add fountain etch or phosphoric acid to maintain an acidity between a pH of 3.8 to 4.6
	Reduced or poor ink	Replace with good ink. Do not reduce ink with varnish unless necessitated by plucking of coated or soft stock
	Greased dampeners	Frequently due to supplying too much ink to press. Correct cause. Wash out dampeners by scrubbing with water followed with gasoline. If too far gone, recover dampeners.

PRESS DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Plate scums, tints, or catches up (Cont.)	Too much gum	Too much gum in fountain solution, or if left on plate without thorough washing following gumming, may emulsify the ink, resulting in scumming. Correct cause.
	Coated paper	Coated paper stock not intended for offset printing will pick off readily and may contain a large percentage of alum or other chemicals that will sensitize plate to grease and cause plate scum. If such stock must be used, frequent wash-ups and more acid in the fountain may be necessary.
	Oxidized Plate	May occur in graining, plate-processing or on the press due to slow drying of water on plate. Application of a strong plate etch may help (See Defective plate,—above), though badly oxidized plates must usually be discarded.
	Old work shows through as "ghost" image	Due to plate or blanket. Plate insufficiently grained to remove old work. Try treatment for Defective Plate, otherwise replace plate. If due to embossed blanket, replace with new blanket and hang old one up to dry.
	Local "catch-up" of ink on plate	May be due to low or high areas in dampeners, or dampeners not contacting plate uniformly. Work up or underlay low areas, place fountain rubber wipers against wetter areas. Adjust dampeners to contact plate uniformly, testing along entire length with thin slips of waxed paper or cellophane for even pull.
	Scumming or "catch-up" on sides.	Frequently caused by drawing dampener covers too tightly over ends of rollers so that dampener diameter is reduced. Correct cause. Work cover to ends by drawing with hands. If severe, under-pack ends of covers with strips of muslin.

PRESS DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Image disintegrates ("Walks away")	Fountain solution too acid or alkaline	Too much acid will dissolve metal and undermine image. Too alkaline a fountain will result in image softening and dissolving away. Keep fountain acidity to a pH of 3.8 to 4.6
	Incorrect packing under plate or blanket	Excessively over or under-packed press-plates or blankets results in considerable surface friction between plate and blanket, wearing away the grain and image. Image usually slurred. Underpack plate to .001" above bearer height, and blanket to bring surface to .003" printing pressure with plate.
	Defective Plate	A press-plate that has been underexposed, has too thick a sensitized coating, or an insecure foundation due to gum remaining in the grain of the plate prior to sensitizing will disintegrate readily on the press. If discovered early, try procedure for "Poor plate" under "Grey Ink Impression"; or obtain new plate.
Paper difficulties	Will not feed properly	Jog paper thoroughly to "break" edges and get air between sheets before placing in press. Adjust feeder to lift paper properly. If insufficient suction, clean vacuum line of accumulated dust and lint. Properly adjust front and side guides, trip, and two-sheet choke.
	Paper plucks in printing	Ink may be too stiff for a coated or soft stock. Reduce with #00 varnish, mixing thoroughly until sufficient varnish has been added to correct condition. Keep record of proportion added to ink for future reference.
	Will not lie flat	Due to humidity variation in paper. Condition to humidity of press-room by hanging or separating stock into small piles. If conditions permit, running the stock through the press blank, or with dampeners against a blank plate if humidity is to be added, is helpful.

PRESS DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Misregister	Uniform displacement of image	Adjust press to register, by shifting front guides, (for minor change only), side guides, or rotating plate cylinder against gear, as required.
	Image twisted on sheet	Small adjustment with front guides, larger adjustment will necessitate shifting plate on plate cylinder.
	Image large or small on plate (both directions)	May be due to incorrect camera setting or to shrinkage or stretch of film negative. If error is small, some correction can be obtained (in direction of press rotation only) by increasing packing under plate and removing packing under blanket by an equal amount to shorten image (resulting size change will be about six times the change of underpacking), and conversely to lengthen image. This may introduce other press difficulties and choice must be made between degree of register desired, as against amount of wear of plate, slur, and gear streaks that can be tolerated. If error is large, shrink or stretch negative to size by placing over warm light table or between damp blotters (or expose new negative) and remake plate.
	Image large or small on paper (both directions)	Due to humidity change in paper since previous run. Maintaining constant humidity in paper is only effective prevention. Some degree of correction can be obtained (time permitting) by conditioning stock by hanging or running through press blank, with or without dampeners against blank plate depending on whether moisture is to be added. Attempt to also condition pressroom by improvised means to agree with that at time of previous run, hanging wet rags or towels in front of fan to increase humidity, or heating press-room to decrease humidity. Minor changes can be corrected in direction of press rotation by changing underpacking (see above). Major

DIFFICULTY	NATURE	REMEDY
Misregister (Cont.)		changes that cannot otherwise be corrected may necessitate obtaining new negative and plate made to register with image on sheet.
	Image long or short in direction of rotation only	Incorrect underpacking. Correct as above.
	Local misregister	At back corners of sheet, may be caused by paper "fanning" out due to varying humidity. Plate stretched at corners or a loose blanket are other causes. Try conditioning paper as for "Image large—on paper" above. Stretching of plate at corners, or pasting paper locally on impression cylinder should only be considered as a last resort.
	Varying misregister	Usually occurs in feeding. Reduce "bounce" of paper by aligning pile to minimum required by side guide, also set tension rollers to just clear back of sheet, with sheet against front guides; and adjust brushes to "hold" sheet. Or reduce speed of press.
Offset of ink	Ink offsets to back of sheet above caused by:	
	(1) excessive ink	Reduce ink distribution at fountain.
	(2) poor ink	If drier has been added and ink does not dry in a reasonable time, with due consideration for the humidity, temperature and varnish added, the ink may be at fault, and another kind should be tried. Old inks may require additional drier and No. 00 varnish.
	Insufficient drier	Some inks require more driers than others. The addition of cobalt drier will speed up drying.
	Coated stock	Coated stock (or a hard finished stock) will require more drier, especially in humid climates. Slower press speeds,

PRESS DIFFICULTIES

DIFFICULTY	NATURE	REMEDY
Offset of inks (Cont.)		application of radiant heat, slip-sheeting, or use of a non-offset spray gun may be necessary.
	Static electricity	Reduce or eliminate static as below.
Static	**Feeding and printing difficulties**	Static is encountered whenever the relative humidity of the press-room falls below 20%. It will evidence itself in the attraction between sheets or between a sheet and the press, interfering with normal feeding and printing. To eliminate, increase humidity of press-room. Reduction of static difficulties may be obtained by stretching tinsel across press at several places along delivery to absorb static charge in paper, and by "grounding" press.

41.—SUMMARY OF PRESS OPERATIONS

1. Hang and condition paper stock where possible.
2. Clean and lubricate press.
3. Jog paper and load squarely on feeder platform.
4. Adjust feeder for size of stock.
5. Adjust side and front guides to preliminary setting.
6. Adjust delivery, setting joggers to sheet size.
7. Mount press plate, with required underpacking, on plate cylinder.
8. Mount blanket on blanket cylinder adding packing necessary to provide .003″ printing pressure.
9. Fill water fountain to proper level with fountain solution.
10. Wet dampening rollers evenly with sponge.
11. Thoroughly mix ink with dryer in required proportions.
12. Distribute ink in fountain.
13. Make preliminary adjustment of ink fountain thumb screws (keys) according to estimated ink requirements of plate.
14. Check form rollers for uniform contact with plate, then release contact.
15. Wash plate with sponge and water.
16. Start press rotating at slow speed.
17. Drop dampeners in contact with plate. Allow press to rotate about a half minute.
18. Drop form rollers against plate to ink up image.
19. Allow press to rotate for about a half minute with dampener and form rollers in contact with plate. (Stop press immediately and sponge with water if non-printing areas take ink).
20. Start pump or turn valves, and feed several waste sheets and a clean sheet through press. (When first sheet reaches guides, engage pressure lever.) Then stop feed, but allow press to continue running.
21. Examine clean sheet for lay, errors, color, and defects.
22. Adjust press as required for obtaining lay or register, ink distribution, etc. (If corrections require stopping press, apply uniform thin coating of gum to plate and fan dry. Blanket must also be washed if plate or guides were adjusted.)

23. Upon completion of corrections, start press into production.
24. Examine sheets periodically removing a sheet after each 50 or 100 impressions and adjust ink fountain or dampener as required until proper balance is obtained.
25. When run is completed, stop press, gum up plate uniformly, fan dry. Remove plate from press, wash ink off with turpentine. Then rub in thin coat of asphaltum if plate is to be retained for future runs.
26. Wash off blanket and prepare press for next plate.

Section VII

MISCELLANEOUS REPRODUCTION PROCESSES

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42. Gelatin Duplicator.— The application of the Gelatin Printing Process to mapping is limited to short editions of line sketches and to overprints of position or other tactical information on existing maps. Since its printing duration is limited to the number of copies that can be obtained from the original inked image, and as the ink supply cannot be replenished, it is evident that the color intensity will diminish with each impression until the ink in the gelatin has been exhausted to the state where further prints are unintelligible.

The inked design is applied to the gelatin surface through the aid of a master copy prepared on the typewriter or by hand. In all instances the printing image will consist of analine dyes of various colors and intensities that have been incorporated into the pencils, inks, carbon paper, or typewriter ribbon.

The Army Gelatin Roll Duplicator utilizes a 15 foot x 22 inch wide roll of gelatin coated paper as its printing foundation, permitting a new area to be reeled into position for immediate use upon completion of the previous printing subject. As the remaining analine dye is gradually absorbed into the gelatin coating, the previous printing areas will be suitable for reuse within a few hours time. (Fig. 5)

The master copy paper is a sheet of a heavy non-absorbent and hard surfaced paper upon which sketches, lettering, tracing and typing can be prepared in one or more colors through the use of hectographic ink, pencils, carbon paper, or typewriter ribbon. Penciling and typing are carried out in the usual way, the only precaution being to avoid embossing of the master sheet by placing it over a hard surface or backing it with several sheets of paper on the typewriter. Where the design is inked in by hand it should be done carefully to provide an even deposit, avoiding concentrated patches or blots where the pen or brush is lifted from the paper. This sometimes can be accomplished by retracing each stroke on the design in the opposite direction. The ink must always be allowed to dry before being transferred to the gelatin. When the master copy is ready for use, the gelatine surface is moistened with a sponge and water, then blotted with several sheets of paper to remove all surface moisture. The master copy is next run through face down in position (through the carriage against the margin bar) on to the gelatin surface and pressed into contact by means of the roller in the carriage. After remaining in contact for about one minute to permit the analine dye image to transfer to the gelatin, the master copy is carefully "peeled" off the gelatin surface.

Where tactical information is to be overprinted on maps, a sheet of hectographic carbon paper is interposed between the map and the master copy, and the required detail then transmitted to the master copy by use of a stylus. A parchmentized master paper is also obtainable that can be placed over the map so that the required data can be penciled or inked directly on its surface. If carbon paper or master copy paper are not available, satisfactory reproductions can frequently be produced by inking or penciling in the required detail (using hectographic materials) on to the map itself and then utilizing the map as the master copy for transferring the printing image to the gelatin.

Impressions are obtained by placing the leading edge of the paper or the map to be overprinted in position through the feed carriage against the margin bar, then passing the feed carriage over the bed to press the paper into contact with the gelatin. Upon returning the carriage, the sheet is picked up off the gelatin. The next sheet can then be inserted and printed.

43. Black and White Process.— The Black and White Process is a photographic method for obtaining direct positive contact prints from a tracing, or transparentized drawing or map. The equipment required includes:

Vacuum or pressure contact printing frame
Arc Lamp (or sunlight)
B & W Developing Machine
B & W Sensitized paper
B & W Developers, Transparentizer and other supplies.

The operating procedure is to first transparentize the map or drawing, then place it face upward in contact with the sensitized surface of the B & W paper, inserting both into the printing frame, and exposing the paper to the sun or arc lamp for one or more minutes (the exact time depending on the intensity of the light source as will have to be determined experimentally), until the cream coloring of the surface is bleached out under the transparent or translucent areas of the map or tracing. The B & W paper is then removed from the frame and passed through the B & W Developing machine so that its sensitized surface is dampened by the rubber roller supported in the developing solution pan. The B & W Paper can also be developed by hand, following exposure, using a sponge or wad of cotton moistened with the developing solution, but will not be as uniform as can be obtained on the machine. (Fig. 6.)

44. Sepia Print Process.— The Sepia, Brown-print, or Vandyke Process, as they are interchangeably called, is used largely for making contact paper negatives from which positive blue prints or photo-litho albumen press-plates can be exposed. It is similar to the blue-print and B & W process in exposure time and handling, but provides a brown negative print of the original transparentized copy or tracing.

The procedure consists of superimposing the tracing or transparentized copy over the sepia print paper, placing them in a vacuum or pressure contact frame and then exposing to an arc lamp or sunlight until the paper has turned a brown color behind the translucent areas of the tracing or printed sheet, but still retains its original light color beneath the drawing and lettering detail.

If proof copy only is desired, and permanency is not essential, as may be required in proof-reading or checking a negative, no further processing is necessary. If however a perman-

ent sepia print is needed, or if it is to be subsequently used as a negative for obtaining further prints or for exposing litho plates, the sepia print must be developed in water for a few minutes until darkened uniformly, and then fixed by placing it in a tray of about 2% solution of hypo (sodium thiosulfate) for about five minutes. The print is next thoroughly washed in water for ten or fifteen minutes, to remove the hypo, and then placed between blotters and dried.

45. Blue Print Process.— The commercial blue print process for obtaining negative prints on paper has little application to map work, but a variation of the process whereby offset press-plates, ground acetate sheeting, or metal mounted drawing paper are sensitized with the blue print solution and exposed to a negative to produce blue guide lines for inking, tusching, opaquing, or stripping, is of considerable value, inasmuch as these blue lines are not greasy or photographically opaque and will not print on the offset press or reproduce in making contact prints or camera negatives.

The blue print sensitizing solution is prepared as follows:

Solution A.	Potassium ferricyanide ------	1 oz.
	Water ----------	6 oz.
Solution B.	Citrate of Iron & Ammonia (green scales) ----------	2 oz.
	Water ----------	6 oz.

Keep separately in dark bottles. For use mix equal parts of solutions A & B.

The Press-plate and metal mounted drawing paper can be coated with this solution in a whirler or by painting the solution on with a wide camel's hair brush; and the paper or film by floating or passing over the surface of the solution and then hanging it up to dry. As the mixed solutions are sensitive to light, all operations must be carried out under subdued light or in a dark-room.

The blue-print sensitized material is exposed through a negative or tracing (held in contact with the material in a vacuum frame) to an arc light or sunlight, for about three to six minutes, as must be determined experimentally. Following exposure, the print is developed in water for several minutes, then intensified with a 1% solution of ammonium dichromate or hydrochloric acid, and thoroughly washed in water for about ten minutes before drying.

46. **Stencil Duplicator.**—The Stencil duplicator ("Mimeograph") is an ink printing device, utilizing a wax coated fibrous stencil mounted over an ink supply drum in the Duplicating Machine to control the transfer of the ink to the paper. (Fig. 7.)

The stencil is prepared for printing by crushing through its wax surface with styluses of several sizes and shapes, or in a typewriter (with ribbon removed), taking care that the crushing only disintegrates the wax coating representing the printing design without injuring the retaining fibers. A corrective fluid for resealing the fibers is furnished to cover up errors that may have occurred in the preparation of the stencil.

The perforated ink supply drum of the machine is prepared for receiving the stencil by first covering its surface with a cloth inking pad (smooth side outward), attaching the pad to the pad hooks on the drum. The ink is then poured into the reservoir, and the drum rotated for a minute or two to distribute the ink and permit it to penetrate through the pad.

The completed stencil is then attached face downward on the stencil stub hooks, the backing sheet withdrawn, the stencil brought around the drum, and its back end secured under the end clamp. The paper stock is placed on the feed table, the side clamp adjusted and the paper then printed by turning the hand crank to feed it through the machine. Adjustments for squaring the image, shifting its location on the sheet, and compensating for the thickness of the sheet are provided in the machine.

47. **Bromide Process.**— The Bromide process, frequently called the Reflection Method, is a simple photographic means for obtaining contact prints from a drawing, printed page or map, that may be printed on one or both sides. It utilizes a slow, high contrast orthochromatic bromide paper, that is selectively exposed by the difference in the light intensity obtained after passing through the bromide paper and being reflected from the surface of the map or printed page behind it. The light source is usually covered with an amber colored screen or sheet of cellophane, and the map or printed page is backed up with a black paper or cloth to avoid the printed matter on the opposite side from showing through. Development, washing, and fixing are the same as that used for any slow bromide paper.

48. Fine Screen Processes:— Although the reproduction of aerial photographs demands the highest rendition of existing detail, few of the available printing methods offer either the range of tone gradation or the degree of resolution obtainable with photographic prints. The 133 line screen used extensively in commercial photographic reproduction, is too coarse when ground detail must be examined under a magnifying glass, and numerous attempts have been made to reproduce finer screens in 300 and 400 lines per inch, or in reticulated, and even continuous tone albumen methods, such as the Bloom Process, with indifferent success, depending largely on the degree of skill and training acquired by the operator.

One of the more successful, though a somewhat involved and time consuming method of fine screen reproduction recently developed, utilizes a 300 line contact film screen with magenta dyed translucent variable density dots, to produce the halftone positive by contact from a continuous tone negative, controlling the degree of subject contrast of the reproduction by the relative exposures through green and magenta filters. This process is completely detailed in a separate instruction pamphlet. An outline summary of the procedure follows:

1. Expose the original continuous tone negative on Kodagraph Commercial Screen Film
2. Develop in the Kodagraph Contact Screen Magenta developer for 3 to 6 minutes at 65°F
3. Rinse in water, then place in a short stop bath consisting of 0.1% solution of Kodak Benzotriazole
4. Fix in X-ray fixing solution until the unexposed silver bromide has dissolved away.
5. Rinse in running water for 1 or 2 minutes
6. Bleach in the following for 3 to 4 minutes until clear:

Solution A	Water (125°F)	1500 cc.
	Sodium Sulphate	200 gm.
	Sodium Carbonate	200 gm.
	Potassium Ferricyanide	75 gm.
	Water to	2000 cc.
Solution B	Water (125°F)	1500 cc.
	Sodium Sulfate	200 gm.
	Sodium Thiosulphate	100 gm.
	Water to	2000 cc.

For use mix 1 part of A with 1 part of B

7. Rinse, place in X-ray fixing bath for 5 to 6 minutes
8. Wash for one-half to one hour to remove hypo and yellow stain.
9. Place Kodagraph contact screen in contact with Kodalith Ortho film, superimpose Magenta negative (as prepared in steps 1 to 8) on contact screen and insert in vacuum frame. Apply vacuum.
10. Expose to Kodagraph printing lamp at a distance of about 5 feet through red and then yellow filter for exposure time previously determined on test strips.
11. Develop film for 3 to 3½ minutes in Kodalith Halftone Developer (at 65°F.)
12. Wash and fix as normal
13. Clear in Farmer's reducer
14. Wash thoroughly
15. Dry.—Result is 300 line screened positive.

Section VIII

MOBILE MAP REPRODUCTION UNITS

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49. General:— The Mobile Map Reproduction Units consist of a complete lithographic and photographic processing organization equipped with the minimum essentials compatable with the probable field requirements and with the necessity for ready mobility. The equipment, processes, and operating procedure will accord with base plant practices, with possible modifications required by their simplification, and influenced by local conditions. The primary environmental factors influencing the operation are:

Climate,— particularly as regards variations in temperature, humidity, and rainfall.

Water supply,— its availability, temperature, and contained impurities.

Terrain,— its adaptability to the establishment of mobile units with especial consideration to camouflage, movement, possible floods, dust, and sand.

50. Establishment of units.— The appointed general location of the map reproduction units will be governed by military considerations, but once designated, immediate attention must be given to positioning, leveling, and the relationship of the individual units to each other to provide an efficient organization. The usual order of procedure will be:

a. Select location, with camouflage, water supply, location of generators or power supply, and coordination with other units as primary factors.

b. Level and block the trailer or truck with the aid of planks, jacks, and improvised supports if necessary. Units containing the press, camera, and plate graining machines must be leveled accurately with a spirit level or plumb bob. The graining unit, in particular, must be adequately braced to absorb the vibration from the contained equipment.

c. Attach, electrical, water supply, drain, and communication lines.

d. Prepare equipment for operation, lubricate where required, clean utensils, and mix solutions. Make tests where necessary to determine the exposure or development time.

51. Water Supply.— The operating procedure in the individual units will be modified by the nature and availability of the water supplied, particularly in the preparation of solutions and the thoroughness with which washing of plates and negatives can be carried out. It may become essential to sacrifice permanency and cleanliness by the necessity to reuse the same water over a period of time, and accordingly facilities for tank or tray washing of negatives and prints and development of press-plates have been included.

The water used must not only be free from visible impurities but should have little chemical effect on the prepared solutions. Water that is "hard", or that contains a considerable percentage of organic matter or dissolved minerals may cause fogging, scumming, or precipitation of some of the chemicals out of the photographic developer solutions, and may also affect the albumen sensitizer used in plate processing. Where a large percentage of such impurities do exist, it is advisable to use distilled, rain, or boiled water for preparation of the photographic and plate-processing solutions, limiting the normal water supply to the washing operations.

Where water purification trucks and adequate filtering facilities are not available and the local supply source (well, spring, or stream), appears turbid, some degree of purification can be effected by utilizing the canvas tank to permit settling of the impurities, and further filtering through available filters or through improvised pads of cheese cloth, interleaved with a square of absorbent cotton, so that the water carried or pumped into the trailers or trucks will be comparatively clear.

Where a water purification system is provided, attention to chlorinating and proper filtering of the water will minimize difficulties due to suspended matter and the possible growth of algae in the pipes and tanks. Complete drainage of the pumps, tanks, and circulating system is of course essential where freezing conditions within the units are anticipated.

52. **Electrical Equipment:—** The mobile map reproduction equipment is designed to operate on 110 V., 60 cycle, single phase, alternating current, to be obtained either from the 5 K.W. portable generators furnished, or from the local power supply source. While this current accords with that normally available over a considerable proportion of this continent, local variations in cycles, voltage, and in the nature of the current itself makes it inadvisable to consider local supply unless authoritative confirmation can be obtained that the electrical source and the capacity of the power lines will be suitable for operation of the equipment. Inasmuch as most foreign electrical power supply is rated at 50 cycles and 220 volts, the portable generator will be the chief source of current.

The standard 5 K.W. portable generator, though rated at 7.2 KVA, with a permissable overload of 75% of the rated maximum for a period of two hours, will nevertheless be found inadequate at times where operation of all equipment is attempted simultaneously, or when required to operate several units off the same generator, and it may be accordingly necessary to judiciously select a program of operation so that equipment required for intermittent service only will function alternately rather than at the same time.

53. **Temperature Control Equipment:—** Some of the mobile camera units are equipped with temperature controlled developing tanks designed to maintain a temperature of 65°F. by heating or cooling the incoming and circulating wash water. The control equipment consists of a refrigeration unit complete with its condenser and air circulation fan, an electrical

heating unit, thermostatic controls, a heat interchange chamber to heat or cool the circulating water, and a circulating pump.

Other units incorporate a complete interior temperature control system to maintain an efficient operating condition within the trailers. All temperature control equipment are somewhat elaborate and critical in their functioning, and care must be observed to implicitly follow the instructions furnished with them. This will include precautions against injury arising from dust, sand, and other impurities, shock, overloading, and freezing weather.

Finally, cold climatic surroundings may necessitate continued heating of the trailer interior both during operation and while inactive or in transit to prevent freezing of the water solutions, and to maintain the press and other units at operating temperature, in this way avoiding the delays, corrosion, and interference with normal procedure that would attend the condensation of moisture on cold equipment.

Section IX

54. Tables.—

WEIGHTS AND MEASURES

LENGTH:

1 inch = 2.54 cm.
1 foot = 30.48 cm.
1 mile = 1760 yards = 5,280 ft = 63,360 inches = 1.60935 kilometers.
1 cm = .3937 inches.
1 meter = 39.37 inches = 3.281 feet.
1 kilometer = 3280.83 feet = .621372 miles.
1 Ångstrőm = .0001 microns = .000 000 0039 inches.

WEIGHT (avoirdupois)

1 ounce = 437.5 grains = 28.35 grams.
1 pound = 16 ounces = .4536 kilograms.
1 gram = 15.43 grains = .035 ounces.
1 kilogram = 2.205 pounds = 35.274 ounces.

CAPACITY (liquid)

1 ounce = 8 drams = 480 minims = 29.57 c.c.
1 quart = 2 pints = 57.75 cu. in. = .946 liters.
1 gallon = 4 quarts = 231. cu. inches = 3.785 liters.
1 c.c. = 16.23 minims
1 liter = 1000 c.c. = 33.815 fluid ounces.
3 parts glacial acetic acid plus 8 pints water = 28% acetic acid.

REPRODUCTION METHODS

	Time required for first print*	Impressions per hour:	Maximum number of impressions per plate	Quality of reproduction	Nature of reproduction	Printing colors
Photo-litho	¾–2 hrs.	3000–5000	50,000–100,000	good	maps, mosaics forms, etc.	1 to 6** or more
Gelatin	¼ hr.	600–3000	25–100	poor	Overprints, instructions	purple & others**
B & W, Ozalid	¼ hr.	20–200	unlimited	fair	Single color positive photo prints of maps sketches, etc.	purple or others
Sepia Print	¼ hr.	20–40	unlimited	fair	negative photo prints, proofs	brown
Blue Print	¼ hr.	15–30	unlimited	poor	negative photo prints	blue
Stencil Duplicating	¼ hr.	2000–12,000	400–5000	poor	typewritten instructions, sketches	black or other colors**
Photographic	¼ hr.	30–60	unlimited	excellent	Photo prints, mosaics, etc.	black
Rapid Printer (Garraway)	½ hr.	500–1500	unlimited	excellent	Photo prints, mosaics, etc.	black

*Minimum times with materials and solutions available. Corrections and art work additional

**Printing colors are inks

(A.G. 062.11 (5-12-42).)

By order of the Secretary of War:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

1415—FORT BELVOIR, VA.—6-24-42—17,000